AKENTEN APPIAH- MENKA UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURIAL DEVELOPMENT

EFFECT OF PARTIAL REPLACEMENT OF MAIZE WITH FULL-FAT SOYA BEAN OR SOYA BEAN OIL ON THE GROWTH PERFORMANCE, GUT pH, CARCASS AND BONE TRAITS OF ROSS 308 BROILER CHICKENS

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A thesis in the Department of Animal Science Education, Faculty of Agriculture Education, submitted to the school of Graduate Studies Akenten Appiah - Menka University of Skills Training and Entrepreneurial Development in partial fulfilment of the requirements for the award of the degree of Master of Philosophy Animal Science (Animal Production and Management)

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DECLARATION

Student's Declaration

I, Ampoma Samuel, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

Ampoma Samuel (Student)
Signature…………………………………..
Date: ………/…………/………………….

Supervisor's Declaration

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis as laid down by the Akenten Appiah- Menka University of Skills Training and Entrepreneurial Development.

Associate Prof. Holy Kwabla Zanu
Signature……………………………………
Date: ………/…………/…………………..

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DEDICATION

I dedicate this thesis to my late brother Obeng Asamoah Benjamin and my lovely wife, children and all my family members.

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LIST OF ABBREVIATION

ABBREVIATION	DEFINITION
ADFI	Average daily feed intake
ANFs	Anti-nutritional factors
BDM	Bone mineral density
BW	Body weight
CP	Crude protein
DM	Dry matter
EU	European Union
FCR	Feed conversion ratio
FFSB	Full fat soya bean
ME	Metabolisable energy
NSP	Non-starch polysaccharides
PA	Phytic acid
SBM	Soya bean meal
SCFA	Short chain fatty acid

ABSTRACT

Soya bean (SB) products are valuable protein and energy source commonly used in poultry diets. Thus, this study was designed to investigate the effect of partial replacement of maize with full-fat soya beans or soya bean oil on growth performance, gut pH, carcass traits and bone characteristics of Ross 308 broiler chickens. A total of 200 broiler chickens were randomly assigned to four dietary treatments T1(regular soya bean diet), T2(full fat soya bean diet), T3(soya bean oil diet) and T4 (regular soya bean diet plus full fat soya bean diet) in a completely randomized design (CRD), with five replicate, ten birds per pen and fifty birds per treatment. Growth performance indicators such as body weight, body weight gain, feed intake, livability, and feed conversion ratio were assessed every two weeks. Gut pH, carcass traits, bone characteristics were also measured. Results showed that on d 14 there was no significant ($P > 0.05$) effect of the treatment on all the growth parameters measured, numerically, all the growth parameters increased but on d 28 of the study, dietary treatment had a significant ($P < 0.05$) influence on feed intake which increased with birds on T3 recording the highest feed intake but statistically was similar to T4 and T1 ($P < 0.05$). Also, from d 42 to 56 there was an increase with a significant difference on dietary treatments on body weight, body weight gain and feed intake of the birds ($P < 0.05$). Dietary treatments had no significant effect ($P > 0.05$) on gut pH across all segments. Gizzard and fat pad were significantly ($P < 0.05$) influenced by the dietary treatment. Regarding bone traits, significant differences ($P < 0.05$) were observed only in tibia length, with birds on T1, T2, and T4 showing longer tibiae than those on T3. In terms of cost benefits, there was significant difference ($P<0.05$) between the treatment means. Birds on soya bean oil diet (T3) and conventional plus full-fat soya bean diets (T4) resulted in increased ($p<0.05$) price per bird, profit, and Performance Efficiency Index (PEI) compared to the birds fed full-fat soya bean diet. In conclusion, using soya bean oil or full-fat soya bean as an alternative energy source by reducing the maize in a diet had positive impact on the growth performance especially at the early stage, carcass traits and tibia length of the birds were optimal.

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Globally, maize and soya bean are primarily used as the main ingredients in chicken feed. Maize grain remains the main source of energy in commercial broiler chicken diets but the price of maize has increased significantly over time due to intense competition for its usage by man or other livestock species and industries (Erenstein, *et al*., 2022). Maize constitutes about 60-70 % in most poultry diet and has a greater acceptance in poultry feeds (Dei et al., 2017). Thus, it is imperative to search for suitable alternative sources of energy in poultry feeds to reduce the cost of production.

Several ingredients like cassava, sorghum, wheat bran, full-fat soya bean, soya bean oil have been identified as suitable ingredients to partially or completely replace maize in poultry diet in an attempt to cut down feed cost (Toomer, 2024). Most of these ingredients that could replace maize contain absorption anti nutritional factors (ANFs) which might hinder the digestion and of nutrients in chicken (Ababor *et al.*, 2023). Elsewhere, vegetable oils are added to chicken feed as a source of energy to reduce the quantity of maize in an attempt to reduce the cost of feeding but in Ghana vegetable oil is not used in formulating chicken diet (Ashong *et al*., 2024).

Soya bean is one of the locally produced protein sources for chicken in Ghana. The oil extracted from soya bean is used for domestic consumption and export (Hailu, *et al*., 2014). However, through diet manipulation, full-fat soya bean or soya bean oil can be used to partially replace maize in commercial chicken diets (Toomer *et al*., 2024). Soya bean oil is produced primarily for human consumption. However, it has become a useful source of feed-grade fat for animals due to a need to formulate high-energy diets for modern breeds. Feed-grade soya bean oil is popularly used in high energy diets, particularly for poultry, because of its high digestibility and metabolizable energy content compared with other vegetable fats/oils (Bergeron, 2021). It is used widely in rations for broiler chickens and growing turkeys as a feed-grade fat to increase energy density of feeds and improve efficiency of feed utilization (Babatunde *et al*., 2021). The high energy value of soya bean oil is attributed to its high percentage of (poly) unsaturated fatty acids, which are well absorbed and utilized as a source of energy by the animal (Castro *et al*., 2019).

1.2 Problem Statement

In recent years, cost of producing broiler birds has gone up due to high cost of ingredient such as maize. There is always shortage of maize because of competition on the usage of maize by man, climate change and other production challenges. Dei (2017) The search for cheaper sources of energy will reduce cost of production of broilers. Ahiwe *et al* (2018). Poultry feed formulation is customized to suit the specific genetic strain, age, and environmental factors influencing the birds. Typically, it comprises a balanced blend of grains, protein supplements, vitamins, minerals, and additives to meet the birds' nutritional requirements Dei. (2017) This has compelled researchers to delve into less cost non - conventional feed sources such as full fat soya bean or soy oil (FFS or SO). Therefore, the purpose of this study was to assess the effects of partial replacement of maize with full fat soya bean or soy oil on growth performance, gut pH, bone breaking strength, and carcass traits of Ross 308 broiler chickens.

1.3 Main Objective

The main objective of the study was to investigate soya bean oil or full-fat soya bean as alternative source of energy to maize in broiler diets.

1.3.1 Specific objectives:

Specifically, the study sought to evaluate the effects of the treatment on:

i. Growth performance
ii. Bone strength
iii. Gut pH
iv. Carcass traits
v. Profitability margin

CHAPTER TWO: LITERATURE REVIEW

2.1 Maize production in Ghana

Maize is one of the most versatile and emerging cereal crops having wider adaptability under varied agro-climatic conditions (Kumar and Jhariya, 2013). There are about 50 species, with a variety of colours, textures, and sizes and forms of grain. Red, yellow, and white are the most widely grown varieties of maize. Animal feed has made significant use of the white and yellow types, which are the most popular (Prasanna, 2012). Maize belongs to the family Poaceae and is widely consumed as a staple food in many countries around the world (Shah *et al.,* 2016). In Ghana, it is considered the second most important staple food next to cassava (Murdia *et al.,* 2016). Maize is the main input in feed production for poultry. Andam *et al*. (2017) reported that over the past five years, Ghana's annual production averaged 1.8 million metric tons per year harvested from approximately 1.02 million hectares. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals (Mwambo *et al.,* 2020).

According Dei (2017), maize constitutes about 50-60% in most poultry diets and has a greater acceptance in poultry feeds. But its production is not sufficient to meet the ever-increasing demand of poultry industry. Also, its price is increasing continuously due to intense competition for its usage by man or other livestock species (Erenstein *et al*., 2022) and starch and allied industries. Maize is a conventional energy source and is currently, the most widely used grain crop in the Ghanaian poultry industry because it provides the bulk of most poultry diets. In terms of total cost, energy is the most expensive item in poultry diets because of the amount required (Olomu, 2011). The nitrogen corrected through metabolizable energy (TMEn) of corn is 3350 kcal/kg compared to 3300 to 3450 kcal/kg for pearl millet (Prandini et al., 2016). Thus, it is imperative to search for suitable alternative sources of energy in poultry feeds to reduce the cost of production. Corn can provide up to 65% metabolizable energy and 20% protein in poultry diets due to its high dietary inclusion rate (Chrysta *et al.*, 2020).

In Ghana, maize (both yellow and white) constitutes approximately 60 % of poultry feed formulations (Andam *et al.,* 2017). When feeding poultry, maize grains are either fed directly or ground and formulated with other suitable feed ingredients. The compounded feed thereafter fed to or transformed into the feed forms preferred by specific livestock species (Dei, 2017). The profitability and growth potential of the poultry industry in Ghana is significantly influenced by the availability and pricing of maize (Dela Cruz *et al.,* 2014). In order to reduce the cost of production and bolster the competitiveness of the local poultry industry, technological and innovative agronomic strategies need to be employed (Murdia *et al.,* 2016).

2.2 Importance of Maize in the Poultry Industry

The preference for maize in poultry feed formulation stems from its accessibility (Shah *et al.,* 2016). Maize contains a vital raw material that has a higher calorific value, more amino acids, and fewer toxins than grains like broken rice and millet (Prandini *et al*., 2016; Andam *et al.,* 2017). For many decades, maize has been a staple food for people. However, in certain jurisdictions around the world, its direct food consumption has decreased over the past few decades due to a variety of factors, including changes in eating patterns and rising income levels (Erenstein *et al.,* 2022). At the same time, maize has become more widely used in industrial applications and as feed for poultry. When utilized at 30 % or more in the diet, yellow kernelled cultivars of maize are preferred as poultry feed because they are a strong source of β-carotenes and xanthophylls that give the skin, poultry fat, and egg yolk their yellow colour (Kaul *et al.,* 2019). Feed production in the poultry industry is the largest end-user of all cultivated maize (Afolayan *et al.,* 2015). Because of the increasing population and growing preference for higher protein intake from meat and eggs, there will likely be a greater need for and demand for maize farming. The relative cheap price and nutritional value of maize make it a more popular choice for poultry feed as compared to wheat and rice (Afolayan *et al.,* 2015).

2.3 Maize as a major feed ingredient

The maize grain is the most significant in terms of poultry feed production or formulation. The other vegetative parts such as stalks, leaves, and young ears are used as forage or fodder for feeding ruminant livestock (Prandini *et al*., 2016). It is known that among the cereal grains, maize has the highest conversion rate of dry matter into animal products like meat, eggs and milk (Jain *et al.,* 2016). The primary source of calories for feeding cattle, pigs, and poultry is maize (Aardsma *et al.,* 2017). The belief that maize has a steady and high nutritional content is one factor contributing to its widespread use in the diets of farmed cattle. Nevertheless, research conducted by Schedle (2016) has shown that maize's nutritional content and chemical composition vary to a greater extent, which makes the generic matrix values for the grain unreliable. The amount of starch, oil, protein, and anti-nutrients in maize determines its nutritional value for poultry (Erdaw *et al.,* 2016).

In Ghana and numerous other countries, maize is considered an essential cereal grain for monogastric farm animals, where it constitutes between 50 % and 60 % of their diets (Manu *et al.,* 2015). It is the main constituent in the majority of pig and poultry diets. Maize is highly palatable, easy to digest, low in fibre, and high in energy. The two main drawbacks of the typical maize cultivars grown in Ghana and other countries are their low protein content (9–10%) and their deficiency in certain essential amino acids, especially tryptophan and lysine (Badu-Apraku and Fakorede, 2017). As a result, it is not a sufficient supply of protein for monogastric. Normal maize contains about 10 % protein, but monogastric animals, including humans, cannot consume this because it lacks two necessary amino acids, tryptophan and lysine (Olabode *et al*., 2021). To achieve a balanced nutrition in poultry production, it necessitates the use of highly rich protein supplements or synthetic amino acids such as lysine in poultry diets containing relatively large proportion of maize (Manu *et al.,* 2015).

2.4 Nutrient Composition of Maize Grain

The nutritional composition of maize includes not only carbohydrates but also essential nutrients like crude protein and phosphorus (Rouf Shah *et al*., 2016). It contains 7.5 %, 3.5 %, 1.9 %, 1.1 % and 3,373 kcal/kg of crude protein, crude fat, crude fibre, ash and metabolizable energy respectively (Rouf Shah *et al*., 2016). Several factors affect the nutritional composition and value of maize. This includes but not limited to environmental conditions, post-harvest handling and genetic variability (Enyisi *et al.,* 2014). Environmental conditions such as edaphic quality, cultivation practices and climate influence nutrient content. Although maize can grow on varied soil types and conditions; however, the best soil type for producing maize with higher nutritional content is well managed loamy because it is rich in essential plant nutrients particularly potassium (K), nitrogen (K), sulfur (S), phosphorus (P) and zinc (Zn) which are necessary for the production of energy dense and protein rich maize (Enyisi *et al.,* 2014). Storage conditions and methods of processing are post-harvest handling that can affect the preservation of nutrients in maize. Genetically, different cultivars of maize have varying nutrient compositions. The quality protein maize varieties (Obaatanpa) have proportionally higher nutritional values as compared to the conventional maize varieties (Accra Local) (Prandini *et al.,* 2016; Badu-Apraku and Fakorede, 2017). In terms of crude protein content, the quality protein maize varieties (Obaatanpa) contain 9.5-10.5 % while conventional maize varieties (Accra Local) contain 8.6 -9.5 % (Mwambo *et al.,* 2020).

2.5 Energy Content of Maize Grain

Maize has been recognized worldwide as a major energy feed ingredient in the diets of poultry due to its high carbohydrate content and palatability (Jain *et al.,* 2016). Maize has a higher metabolizable energy value (3,365 Kcal/kg) (Afolayan *et al.,* 2015) than other potential poultry feed sources, such as rice (3,320 Kcal/kg), rice bran (2,620 Kcal/kg), peanuts (2,915 Kcal/kg), and oilcake (2,350 Kcal/kg) and as a result it is frequently used as a standard for measuring other energy feed sources (Andam *et al.,* 2017; Aardsma *et al.,* 2017). In poultry feed industry, maize which constitute a greater percent of the diet, is the most often used energy source (Dei, 2017). Corn is the most popular because of its easy availability and higher energy content. The feed and poultry industry standard for energy requirements in chickens is 3,200 kcal/kg for broilers and 2,600 kcal/kg for layer feed (Hellin *et al.,* 2013).

2.6 Protein Content of Maize Grain

The protein content of the maize grain is low, with a standard error of about 7 g/kg of crude protein (Barros *et al.,* 2017). Eight (8) to eleven (11) g of protein per 100 g of dry matter are found in maize grain. The amount of protein in the different grain fractions varies greatly. The germ has significantly more protein (184 g/kg DM) than the endosperm (80 g/kg DM), although the endosperm contains the majority of the grain's protein (Dei, 2017). In general, the grain's low protein content typically limits its nutritional value for both human and animals (Barros *et al.,* 2017. Each protein fraction's amino acid content and the relative proportions of the different protein fractions determine the overall maize grain's amino acid composition (Gebru *et al.,* 2019).

The proteins found in maize grain endosperm are commonly known as albumins, globulins, prolamins, and glutelins, depending on which solvent system they dissolve in. Glutamins and prolamins, commonly known as storage proteins, are only found in the endosperm, while albumins and globulins, generally known as water-soluble proteins, are also present in the germ and the aleurone layer (Ortiz-Martinez *et al.,* 2017). Approximately 50–60% of the total protein in typical maize grain is prolamin, which has a higher proportion than glutelin (Chen *et al.,* 2018). The relative proportion of each protein fraction has a significant impact on the amount of each individual amino acid in the total grain protein. Each protein fraction typically has a distinctive amino acid composition. Because lysine is the most deficient prolamin, maize protein has a low nutritional value (Ortiz-Martinez *et al.,* 2017; Chen *et al.,* 2018). In essence, the overall lysine deficiency in maize grain results from its low albumin and globulin content, which, in addition to having a high lysine content, shows a well-balanced amino acid composition comparable to that of animal proteins with greater nutritional value (Ahmed *et al.,* 2023). Additionally, maize prolamins have higher levels of leucine than isoleucine, which results in the common amino acid imbalance that lowers maize's protein quality (Gebru *et al.,* 2019).

2.7 Non-Conventional Feed Materials for the Study

The rising cost of conventional feed ingredients, such as maize and soya beans, has made poultry production more expensive, particularly for small and medium-scale farmers. As a result, there is growing interest in utilizing non-conventional feed ingredients that are locally available and often more affordable. Non-conventional feeds refer to alternative ingredients such as agro-industrial by-products, leaves, and other plant materials not traditionally used in poultry diets. These feeds have the potential to reduce feed costs, enhance sustainability, and support the growth of poultry in resource-limited settings (Tenza *et al.,* 2024). However, the use of non-conventional feeds also poses certain challenges regarding nutrient availability, palatability, and potential anti-nutritional factors (ANFs).

Studies have shown that non-conventional feed ingredients can have varying effects on the growth performance of poultry, depending on their nutrient composition and inclusion levels. For example, cassava peels, which are high in fibre but low in protein, may reduce growth rates if included at high levels without proper supplementation (Adeyemo *et al*., 2020). However, when supplemented with protein-rich ingredients such as moringa or soya bean meal, cassava peels can be effectively utilized in poultry diets without negatively affecting performance (Ogbuewu *et al*., 2023).

One of the main challenges associated with non-conventional feeds is the presence of ANFs, which can inhibit nutrient absorption and reduce the overall performance of poultry. For example, cassava peels contain cyanogenic glycosides, which can be toxic if not properly processed (Panghal *et al*., 2021). Similarly, Leucaena leaves contain mimosine, an alkaloid that can cause toxicity in poultry if consumed in large quantities (Ramli *et al*., 2017). Proper processing methods such as drying, boiling, or fermentation can help reduce the levels of ANFs in non-conventional feed ingredients, making them safer for poultry consumption.

2.7.1 Exploring non-conventional feed resources for sustainable livestock production in developing countries

The availability of feed resources and their rational utilization for livestock represents possibly the most compelling task facing planners and animal scientists in the world. The situation is acute in numerous developing countries where chronic annual feed deficits and increasing animal populations are common, thus making the problem a continuing saga (Ramli *et al*., 2017).

Thus, non-conventional such as full fat or soya bean oil feeds could partly fill the gap in the feed supply, decrease competition for food between humans and animals, reduce feed cost, and contribute to self- sufficiency in nutrients from locally available feed sources (Mashiloane *et al.,2025)*. It is therefore imperative to examine for cheaper non-conventional feed resources that can improve intake and digestibility. Feedstuffs such as fish offal, cassava peel, palm kernel cake, sugarcane bagasse, unrefine soya bean oil, refine soya bean oil, rice bran, maize bran, cocoa bean waste, coconut meal, corn cob, moringa leaf, leucaena leaf, local brewery and distillery by-products, sisal waste, and coffee pulp are commonly used in Ghana and could be invaluable feed resources for small and medium size holders of livestock (Ramli *et al*., 2017).

2.8 Soya Bean Production in Ghana

The soya bean (*Glycine max*) is an annual herbaceous erect plant that ranges in height from 30 to 183 cm (Mishra *et al.,* 2024). It has fine brown or grey hair on its stem, leaves, and pods. Soya beans, like peas, beans, lentils, and peanuts, are members of the Leguminosae or Fabaceae family. Soya beans have about 8 % of seed coat or hull, 90 % of cotyledon and 2 % of germ (Mishra *et al.,* 2024). Originally from East Asia, it has spread throughout the world, with the United States, Brazil, and Argentina being the leading producers (Bankole, 2022). It is mainly used for vegetable oil and oilseed meal production for use in feeding animal. The key factor boosting soya bean production has been the increase in the use of soya bean as a protein substitute for animal protein diets (Mawiya, 2016). The major farmed animal species diets containing soya bean include poultry, pigs, cattle and aquatic. In some animal feeds, soya bean is utilized comparatively more than in others. The primary goal is to supply pigs and poultry with high-quality protein (Mawiya, 2016). Out of all the plant protein sources, the majority of the land required for production of animal product is devoted to the cultivation of soya bean (Thrane *et al.,* 2017). For instance, the United States of America (USA) and the European Union (EU) both utilize a lot of soya bean in animal feed. Soya bean acreage of 5.0 million hectares in Brazil and 4.2 million hectares in Argentina is required for the EU's yearly livestock consumption alone. Therefore, because of its high protein content, energy contribution, and physiological advantages, soya beans continue to be essential in poultry nutrition (Thrane *et al.,* 2017). It provides the main sources of high-quality protein and energy and is essential for maximizing feed efficiency, growth performance, and poultry health in general (Mawiya, 2016).

2.8.1 Nutrient composition of soya bean

In broiler chickens, soya beans are regarded as a great source of protein and oil (Bankole, 2022). They include 20 % oil and 38 % crude protein as in Table 2.1. As a result, they are regarded as the most cost-effective since they eliminate the need for extra oils in the diet (Muslyumova *et al.,* 2021). As the most popular vegetable protein in animal feed, soya beans are a great feed substitute for animal proteins due to their high protein content (44–48 %) and balanced amino acid profile. However, raw soya bean meal contains anti-nutritional factors that reduce its digestibility and utilization (Alagawany *et al.,* 2019). Animal performance is adversely affected by these anti-nutritional compounds, which include non-starch oligosaccharides, polysaccharides, lectins, tannins, saponins, phytate, protease inhibitors, and antivitamins (Nabizadeh *et al.,* 2018). Soya beans need to be heated and under high pressure to lessen the effects of these chemicals, but heat treatment must be done carefully to prevent protein and other vital components from being denatured (Avedeweh, 2015).

Table 2. 1: Nutrient Composition of Soya Bean Grain

Parameter	**(%)**
Moisture content	9.000
Crude fat	15.50
Crude protein	43.20
Crude fibre	16.77
Carbohydrate	9.530
Ash content	6.000

Source: Avedeweh (2015)

2.8.2 Crude Protein and Amino Acids Content in Soya Bean

According to Muslyumova *et al.* (2021), the soya bean seed has the highest crude protein content (about 40%) and the best amino acids among all the legume seeds. According to Thrane *et al.* (2017), soya bean protein contains all the essential amino acids required to meet nutritional needs of poultry for development, maintenance, and growth. Protein serves as the building block for organs, muscle, feathers, and eggs (Alagawany *et al.,* 2019). He *et al.* (2021) claimed that birds' daily diets must contain ten amino acids; however, this contradicts report of Classen (2017) who opined that pigs and poultry nutrition require only five important amino acids, namely tryptophan, cysteine, theronine, methionine, and lysine. Soya bean has the highest lysine digestibility (91%) (Classen, 2017); it also high in methionine, cysteine, and theronine digestibility (He *et al.*, 2021).

Carbohydrate content of soya bean

In addition to being high in protein, soya beans are also high in carbohydrates (Al Loman *et al*., 2016). Poultry use glucose, which is produced from carbohydrates, as an energy source for development and egg production. Adebowale *et al.* (2019) clarified that monogastric animals have poor digestion of the carbohydrate components (hulls, sugars, and non-starch polysaccharides). About 10% of the carbohydrates in soya beans are free sugars (5% sucrose, 4% stchyyose, and 1% Raffi nose) (Al Loman *et al*., 2016; Nguyen *et al.,* 2021). Since monogastric animals lack the enzymes necessary to hydrolyze these carbohydrates, bacterial fermentation is used to digest these fibres (Adebowale *et al.,* 2019). Soluble non-starch polysaccharides (polymers that are partially soluble in water) and insoluble non-starch 13 polysaccharides (cellulose) are the two primary categories of non-starch polysaccharides (Nguyen *et al.,* 2021). In chickens, insoluble non-starch polysaccharides (cellulose) can impair growth performance and decrease nutrient digestibility. Soya bean meals must have 35–40% carbohydrates when oil is produced (Choct, 2018).

2.8.3 Crude Fat Content of Soya Bean

One of the main sources of nutritional energy in poultry feed is crude fat, also known as ether extract. The amount of crude fat in soya beans might vary greatly according to the processing method used. Full-fat soya beans (FFSB) are a high-energy feed item because they normally contain 18–20 % crude fat (Tang *et al*., 2024). However, as most of the oil is eliminated during processing, solvent-extracted soya bean meal (SE SBM), the most popular type in commercial chicken feeds, has as little as 0.5–1 % crude fat (Kerr *et al.,* 2023). A compromise between cost and energy contribution is provided by expellerprocessed soya bean meal, which preserves roughly 6–7 % fat through mechanical extraction as opposed to chemical extraction (Kerr *et al.,* 2023).

In broilers and layers, it has been demonstrated that adding high-fat soya bean products, like FFSB, improves energy density and feed conversion. However, it is important to balance the amount of protein and energy in the diet. Overconsumption of fat can result in increased deposition of fat in the abdomen, which is undesirable for carcass quality, particularly in broiler chickens (Ali *et al.,* 2022). The significance of regulated inclusion levels was highlighted by a study by Al-Marzooqi and Leeson (2016), which showed that diets heavy in soya bean oil or fat enhanced energy utilization but also increased fat pad weights.

The unsaturated fatty acid fat found in soya beans mostly improves meat quality by increasing tenderness and lowering the amount of saturated fat in poultry meat (Wang *et al.,* 2017). As a result, the fat content of soya bean products does not influence growth performance of poultry but also affect the nutritional value of poultry products intended for human consumption.

2.8.4 Crude Fibre Content of Soya Bean

Crude fibre is a measurement of the amount of indigestible cellulose, pentosans, lignin, and other comparable substances present non feed (Slominski, 2018). Crude fibre is essential for gut health and digestive efficiency, despite being frequently viewed as a less desirable part of chicken diets because of the birds' poor capacity to digest fibrous materials. Processing also affects the amount of crude fiber in soya bean products. While non-dehulled or hull-containing soya bean meals may include up to 7–14 % crude fibre, dehulled soya bean meal can have as little as 3–5 % (Okonkwo *et al.,* 2023). Unless added in very small amounts or processed with enzymes, soya bean hulls a by-product of processing can contain more than 50 % crude fibre (Adewole *et al.,* 2016), making them an unsuitable option for monogastric animals like chicken.

For instance, diets with slightly higher levels of dietary fiber from soya bean hulls or full-fat soya bean by-products were linked to increased intestinal villus height and improved nutrient absorption in broilers (Singh *et al.,* 2018). However, excessive fiber, especially when undigested, can reduce nutrient availability and feed efficiency, resulting in lower growth rates and increased feed costs. Even though poultry lack the complex digestive systems necessary to ferment fiber efficiently, moderate inclusion of dietary fiber has been shown to promote intestinal development, gizzard function, and beneficial microbiota populations (Jiménez-Moreno *et al.,* 2019). This means that when adding high-fibre soya bean products to chicken diets, fibre-degrading enzymes like xylanase and cellulase must be used. It has been demonstrated that this type of enzyme supplementation enhances the use of fibrous components, especially in feeds formulated from soya bean (Masey O'Neill *et al*., 2020).

2.8.5 Mineral Content of Soya Bean

Poultry's nutritional needs for minerals are largely met by dietary soya bean. Calcium (Ca), phosphorus (P), potassium (K), magnesium (Mg), and sulfur (S) are among the essential macro and microminerals found in it. Soya beans contain roughly 0.20–0.25 % calcium and 0.59–0.65 % total phosphorus, although only 0.20–0.21 % of this is accessible to chicken because of the high phytate-bound proportion, according to Olukosi *et al.* (2017).

Magnesium and sulfur are present at 0.21–0.27 % and 0.30–0.43 %, respectively, while potassium level ranges from 1.7 to 1.97 %. As stated in table 2.2. There are also appreciable concentrations of microminerals including zinc (35–60 ppm), copper (15–28 ppm), iron (75–160 ppm), and manganese (27.5–32.3 ppm) (Lee *et al.,* 2022).

Because phytate chelates and phosphorus make it unavailable to monogastric animals, phosphorus digestibility is a major concern in poultry nutrition (Bougouin *et al.,* 2015). The necessity for standardization was highlighted by Rojo *et al.* (2023), who discovered that the phosphorus digestibility in SBM varied from 35.3 % to 63.2 % based on the soya bean source and processing. Phosphorus availability has been demonstrated to be enhanced by autoclaving and enzymatic treatments, especially the addition of microbial phytase (Walk *et al.,* 2021). Studies have shown that supplementing soya bean with phytase improved the digestibility of ileal phosphorus from 46 % to 61 %, with higher enzyme dosages achieving up to 77 % digestibility (Adeola and Cowieson, 2016; Walk *et al.,* 2021). In a similar vein, autoclaving soya bean has been shown to increase phosphorus bioavailability by breaking up phytate complexes (Ravindran *et al.,* 2017).

Table 2. 2: Mineral Composition of Soya Beans

Mineral	**Composition**
Calcium (Ca) (%)	0.200–0.250
Potassium (K) (%}	1.700–1.970
Sodium (Na) (%)	0.040
Phosphorus (P) (%)	0.590–0.650
Magnesium (Mg) (%)	0.210–0.270
Chloride (Cl) (%)	0.020–0.030
Sulfur (S) (%)	0.300–0.430
Chloride (Cl) (%)	0.020–0.030
Copper (Cu) (ppm)	1500–28.00
Iron (Fe) (ppm)	75.00–160.0
Selenium (Se) (ppm)	0.100
Zinc (Zn) (ppm)	35.00–60.00
Manganese (Mn) (ppm)	27.50–32.30

Source: (Lee *et al.,* 2022; Olukosi *et al.*, 2016)

2.8.6 Vitamin Composition of Soya Bean

Soya bean contains a variety of vitamins that promote the poultry's physiological processes as in table 2.3. These include water-soluble B-complex vitamins and fat-soluble vitamins like vitamin E. Vitamin E, an essential antioxidant that promotes immune system function and preserves cellular integrity, is found in soy beans (Surai, 2016). According to Nguyen *et al.* (2021), soya beans typically contain 3.0–6.6 mg/kg of vitamin E. The most prevalent B-vitamins are pantothenic acid (13.2–13.8 mg/kg), thiamin (1.7 mg/kg), riboflavin (2.6–

4.4 mg/kg), and niacin (20.9–59.8 mg/kg). Choline, which is essential for lipid metabolism and liver function in poultry, is present at roughly 2673–2850 mg/kg (Olukosi and Adeola, 2017), while biotin and folic acid are detected in the range of 32.0–320 µg/kg and 450–700 µg/kg, respectively (Batal and Dale, 2016).

The processing techniques, however, can have a significant impact on the vitamin concentration and bioavailability. Trypsin inhibitors and other anti-nutritional factors must be deactivated by heat treatment, which can also degrade heat-sensitive vitamins like folic acid and thiamin (Krautwald-Junghanns *et al.,* 2022). Overheating decreased the levels of riboflavin and vitamin E, which may compromise the nutritional value of soya bean (Nguyen *et al.,* 2021). Therefore, maintaining the soya bean's vitamin integrity requires optimizing processing techniques.

Table 2. 3: Vitamin Composition of Soya Bean

Vitamin	**Composition**
Vitamin E (mg/kg)	3.000–6.600
Thiamin (B1) (mg/kg)	1.700
Riboflavin (B2) (mg/kg)	2.600–4.400
Niacin (Vitamin B3) (mg/kg)	20.90–59.80
Pantothenic Acid (B5) **(**mg/kg)	13.20–13.80
Biotin (B7) (µg/kg)	32.00–320.0
Folic Acid (Vitamin B9) (µg/kg)	450.0–700.0
Choline (mg/kg)	2673–2850

Source: (Surai, 2016; Nguyen *et al.,* 2021)

2.8.7 Full-fat soya bean (FFSB) Processing and its Importance

Full fat soya bean are complete soya beans in which the oil has not been extracted. The product is made using a number of techniques, including dry or wet extrusion, frying, autoclaving, roasting, and micronizing to deactivate the ANFs. Raw soya bean contain anti nutritional factors like trypsin inhibitors, phytates and lectins which can impair nutrient utilization and cause digestive issues (Das, 2019). Various methods can reduce ANTs including heat method and enzyme treatment. Processing soya bean improve protein digestion, increase energy availability and reduce ANTs. Depending on the extent of heat damage or ANF inactivation, each of these procedures has a unique effect on the soya bean's nutritional value (NRC, 1994).

Full fat soya bean is processed by removing impurities and dry the beans to moisture content of 10-12% heat the raw soya beans to 248-266F for 20-30 minutes, stirring occasionally, to inactivate trypsin inhibitors. Allow the soya beans to cool then grind them into meal (Zhan et al., 2022).

Table 2. 4: Nutritional Composition of Full Fat Soya Bean

Parameter	Full fat soya bean
Dry Matter (%)	89.40
Crude Protein (%)	37.10
Crude Fibre (%)	5.100
Ether Ext ract (%)	18.40
Ash (%)	4.900
Gross Energy (MJ/kg)	20.95

Source: Voss *et al.* (2018).

2.8.8 Impact of Full-Fat Soya Bean Diet on the Growth Performance of Broilers

Numerous studies confirm that including processed FFSB in broiler diets significantly improves body weight gain. Karunaratne *et al*. (2023) demonstrated that broilers fed diets containing up to 20 % extruded FFSB exhibited superior weight gains relative to birds on soya bean meal (SBM) and supplemental oil-based diets. The improvement was attributed to enhanced energy provision and superior protein quality. Alagawany *et al*. (2022) similarly reported increased average daily gains (ADG) in broilers fed 15 % extruded FFSB diets during both starter and grower phases. These enhancements in BWG are linked to better utilization of dietary nutrients when ANFs are adequately neutralized. Conversely, Raji *et al*. (2021) highlighted that raw or insufficiently processed FFSB negatively impacts BWG, mainly due to residual trypsin inhibitor activity interfering with protein digestion.

Feed intake in broilers is influenced by diet palatability, nutrient density, and textural quality. Bello and Olomu (2023) found that the inclusion of extruded FFSB slightly increased feed intake in broilers due to improved pellet quality and reduced dustiness from inherent oil content. Similar findings were reported by El-Safty *et al*. (2022), who observed enhanced feed consumption in broilers fed diets containing 10-15 % FFSB. However, excessive inclusion of poorly processed FFSB may depress feed intake due to bitterness from residual anti-nutritional compounds (Mabelebele *et al*., 2021). Thus, optimal inclusion levels combined with adequate processing are essential to maximize palatability and intake.

Feed conversion ratio is a pivotal parameter reflecting the efficiency of feed utilization for body weight gain. Several researchers have noted that broilers fed FFSB-based diets demonstrate improved FCR compared to conventional SBM diets supplemented with oil (Bello and Olomu, 2023). Karunaratne *et al*. (2023) observed that inclusion of extruded FFSB at 15-20 % in broiler diets consistently yielded better FCR values, indicating more efficient nutrient utilization. This efficiency is attributed to the readily available dietary lipids from FFSB, which reduce metabolic energy expenditures associated with digestion (Alagawany *et al*., 2022). Nevertheless, inclusion rates exceeding optimal levels or inadequate thermal processing can compromise FCR due to impaired nutrient availability and increased energy demand for detoxification of ANFs (Raji *et al*., 2021).

Processing full-fat soya beans is critical in enhancing their nutritional value for broiler diets. Among various methods, extrusion is the most effective, as it efficiently inactivates ANFs while preserving nutrient integrity (Ravindran, 2023). Studies by Mabelebele *et al*. (2021) indicated that broilers fed extruded FFSB exhibited higher apparent metabolizable energy (AME) and protein digestibility, culminating in improved BWG and FCR. Autoclaving and roasting are also effective, but extrusion remains superior in preserving oil integrity while neutralizing ANFs (Bello and Olomu, 2023). Raji *et al*. (2021) demonstrated that improper heat treatment led to significant reductions in BWG and poorer FCR in broilers.

The impact of FFSB inclusion varies across different growth phases in broilers. Adeyemo *et al*. (2020) emphasized that starter-phase broilers benefit most from FFSB inclusion, particularly due to higher energy requirements during early rapid growth stages. Inclusion rates of 10-15% were found to be optimal for achieving significant BWG improvements in young chicks (El-Safty *et al.*, 2022). During grower and finisher phases, birds exhibit tolerance to higher FFSB inclusion levels (up to 20 %), provided the diets are isonitrogenous and supplemented with limiting amino acids (Karunaratne *et al.*, 2023). Gradual incorporation of FFSB, with concurrent amino acid fortification, maximizes its benefits throughout the production cycle.

Comparative evaluations highlight the efficacy of FFSB relative to conventional SBM and supplemental oil diets. Bello and Olomu (2023) noted that broilers fed FFSB-based diets not only exhibited comparable or superior growth metrics but also benefited from improved feed homogeneity and potentially lower formulation costs. Similarly, Alagawany *et al.* (2022) emphasized that substituting SBM plus oil with FFSB simplifies diet formulation and reduces ingredient variability. However, attention must be paid to amino acid balance, especially regarding methionine and lysine levels (Karunaratne *et al.*, 2023).

2.8.9 Soya Bean Oil Production and Uses

Soya bean oil is produced primarily for human consumption. However, it has become a useful source of feed-grade fat for animals due to a need to formulate high-energy diets for modern breeds. Feed-grade soya bean oil is popularly used in high energy diets, particularly for poultry, because of its high digestibility and metabolizable energy content compared with other vegetable fats/oils (Bergeron, 2021). It is used widely in rations for broiler chickens and growing turkeys as a feed-grade fat to increase energy density of feeds and improve efficiency of feed utilisation (Babatunde *et al.*, 2021). The high energy value of soya bean oil is attributed to its high percentage of (poly) unsaturated fatty acids, which are well absorbed and utilised as a source of energy by the animal (Castro *et al*., 2019). Also, the high polyunsaturated fatty acids (PUFA) in soya bean oil appears to have an energy independent effect on improving reproduction in dairy cattle (Rahbar *et al*., 2014), and this has been attributed to the role of linoleic acid in reproduction (Szczuko *et al*., 2020).

2.9 Use of Fats and Oils in Poultry Diets

Fats and oils are normally used as an energy source in poultry diets due to its high energy density. Fat energy is at least twice that of protein and carbohydrates (NRC, 1994), and metabolizable energy values are around 37.7 kJ for 1 gram of fat, 16.7 kJ for 1 gram of protein and 16.7 kJ for 1 gram of carbohydrates (Singh *et al*., 2017). Lipid addition has other benefits including a reduction in dustiness and binding of other nutrients, improved palatability and lubrication of equipment during preparation of food which improves pellet quality (Baião and Lara, 2005). Fat-supplemented diets increase feed efficiency and profitability in poultry (Sahito *et al*., 2012). Besides, oil improves the palatability of diets, reduces the dustiness of feeds and decreases the passage rate of feed through the intestinal tract of poultry, which gives more time for the adequate absorption of all nutrients present in the diet (Baião and Lara, 2005).

The inclusion of fat and oil is a common practice in modern poultry production to increase the Fat and oil are commonly used in poultry diets to increase the energy density as they yield 2.25 times more calories than carbohydrates and protein energy content of diet. The addition of fat to diets, besides supplying energy, improves the absorption of fat-soluble vitamins, diminishes the pulverulence, increases the palatability of the rations, and increases the efficiency of the consumed energy (lower caloric increment) (Olabode *et al* 2021). Furthermore, it reduces the passage rate of the digesta in the gastrointestinal tract, which allows a better absorption of all nutrients present in the diet. High energy diets have been shown to improve growth and feed efficiency (Lammers et al.,2000). Oils added to the rations of animals are effective on the fatty acid composition and amount of abdominal fat. In fact, fatty acids composition of oils used in poultry rations are reflected in the animal products because dietary fatty acids are incorporated with little change into the bird body fats (Williams *et al*., 2022. Thus, the type of fat used in the feed influence the composition of broiler body lipids. Abdominal fat is a good indicator of chicken body fats because it is very sensitive to changes in dietary fatty acid composition. Crespo *et al*. (2001) have reported that broiler chickens fed with diets enriched of polyunsaturated fatty acids have less abdominal fat or total body fat deposition than do broiler chickens fed with diets containing saturated fatty acids.

Barbour (2006) reported that by increasing the proportion of supplemental animal-vegetable blend fat from 0 to 60 g/kg in isocaloric diets (2,963 kcal/kg), feed conversion was improved without any effects on BW, feed intake, abdominal fat, or whole carcass composition. In a subsequent experiment, 30, 60, or 90 g/kg of corn oil added to isocaloric corn-soya bean meal diets (2,926 kcal/kg) increased BW in four weeks old male broilers compared with those fed equal quantities of diets with no added oil. Those improvements in performance were related to enhanced use of calories beyond what was accounted for in terms of calculated dietary ME, and this was especially true in the case of vegetable oils. In more recent studies, linear increases in weight gain and feed efficiency were observed when male broiler chickens were fed corn-wheat-soya bean meal diets in which ME was increased from 2,800 to 3,000 kcal/kg through changes in supplemental soya bean oil or dietary carbohydrate levels (Williams *et al* 20220).

2.10 Effect of Soya Bean Meal on the Growth Performance of Broilers

Soya bean meal (SBM) is a widely used protein source in poultry diets due to its high protein content, balanced amino acid profile, and digestibility (Abdel-Raheem *et al*., 2023). It is obtained as a by-product of soya bean oil extraction and serves as an economical alternative to fishmeal and other protein sources in broiler diets. The nutritional value of SBM is influenced by processing methods, which determine its amino acid availability and overall quality (Asghar *et al*., 2024). Its inclusion in broiler diets has been extensively studied for its impact on growth performance, including body weight gain, feed intake, and feed conversion efficiency.

Several studies have demonstrated that broilers fed diets containing SBM exhibit improved growth performance compared to those on diets with lower-quality protein sources. Olukosi *et al*. (2017) found that replacing fishmeal with SBM resulted in comparable weight gain and feed conversion ratios (FCR) in broilers. This is attributed to SBM's high crude protein content (44-48%) and favourable amino acid composition, particularly lysine and methionine, which are essential for muscle growth and development. The digestibility of SBM is another critical factor influencing broiler growth. According to Anyiam *et al*. (2025), the digestibility of amino acids in SBM is superior to other plant-based protein sources, leading to better nutrient utilization. However, the presence of anti-nutritional factors such as trypsin inhibitors and lectins may reduce protein digestibility if not properly processed (Thakur *et al*., 2019). Heat treatment and enzyme supplementation have been shown to enhance the digestibility and efficiency of SBM-based diets, ultimately improving broiler performance.

SBM's impact on feed intake is also well-documented. Broilers tend to consume diets containing SBM more readily than those with lower digestibility protein sources, such as sunflower or cottonseed meal (Amerah,*et al,* 2015). This is likely due to its palatability and amino acid balance, which meet the nutritional requirements of growing broilers. Higher feed intake, coupled with improved nutrient utilization, results in better overall growth performance. The effect of SBOM on the feed conversion ratio (FCR) is significant in poultry nutrition research. Studies by Wu *et al*. (2019) indicate that broilers fed SBM-based diets achieve lower FCR values, meaning they convert feed into body mass more efficiently than those on alternative protein sources. This improved efficiency can be attributed to SBM's highly digestible protein and essential amino acids, which optimize metabolic functions and muscle accretion.

Economic considerations also play a crucial role in the inclusion of SBM in broiler diets. Given its relatively low cost compared to animal protein sources, SBM provides a cost-effective means of meeting broilers' protein needs while maintaining optimal growth rates (Amer *et al*., 2021). Moreover, the global availability of SBM makes it a sustainable choice for poultry producers seeking to reduce feed costs without compromising bird performance. The effect of SBM on carcass traits is another aspect of interest. Research by Hussein *et al*. (2020) suggested that broilers fed SBM-based diets exhibit improved carcass yield, particularly in breast muscle development. Additionally, the fat content of broiler meat may be influenced by dietary SBM levels, with some studies reporting lower abdominal fat deposition in birds fed higher levels of SBM (Katoch *et al*., 2022).

Despite its numerous benefits, SBM inclusion in broiler diets must be optimized to prevent nutrient imbalances. Excessive dietary SBM levels can lead to amino acid imbalances and suboptimal growth performance (Ravindran *et al*., 2017). Therefore, proper formulation and supplementation with synthetic amino acids, such as methionine and lysine, are recommended to ensure an ideal nutrient profile for broilers. Recent advancements in feed technology have explored the combination of SBM with feed additives like probiotics, enzymes, and organic acids to enhance its nutritional value further (Zhang *et al*., 2022). These additives help improve nutrient absorption, reduce the impact of anti-nutritional factors, and optimize growth performance.

2.11 Effect of Soya Bean Oil on Carcass Traits in Broilers

Soya bean oil is widely used as an energy-rich lipid source in broiler diets. Its inclusion in poultry feed has shown significant effects on carcass traits, including dressing percentage, fat deposition, and meat yield. These effects are mainly attributed to its high energy density and essential fatty acid content, especially linoleic acid.

According to Afolayan *et al*. (2015), dietary inclusion of soya bean oil at 4–6% significantly improved carcass yield and breast muscle weight in broilers. However, higher levels led to increased abdominal fat deposition, indicating the importance of balancing energy levels in feed formulation. Similarly, Arteaga-Wences *et al*. (2021) reported that soya bean oil enhanced feed efficiency and promoted better muscle-to-fat ratios in broiler carcasses.

One of the primary effects of SBO on broiler carcass traits is its influence on carcass yield. Studies have shown that broilers fed diets with optimal levels of SBO exhibit higher dressing percentages compared to those on alternative protein sources such as sunflower or cottonseed meal (Ven der Merve *et al.*, 2019). This can be attributed to SBO's high lysine content, which plays a crucial role in muscle growth and protein deposition (Olukosi *et al.*, 2017). Properly balanced SBO inclusion ensures that birds reach market weight with minimal carcass waste.

Breast muscle development is another critical aspect of carcass traits affected by SBO. As a rich source of fatty acid, SBO enhances calories synthesis, leading to improved breast meat yield and fat pad Research by Wu *et al.* (2018) found that broilers receiving SBO-based diets had significantly larger breast muscles compared to those fed lower-quality protein sources. Since breast meat is a highly valuable portion of the broiler carcass, optimizing SBO inclusion in diets enhances profitability in poultry production. The impact of SBO on abdominal fat deposition is also well-documented. While protein sources influence muscle growth, they can also affect fat accumulation. Studies indicate that broilers fed high levels of SBO tend to have high abdominal fat compared to those receiving diets with lower-quality protein sources (Gilbert, 2011). This is attributed to SBOs favourable energy-protein ratio, which increases excessive fat deposition while promoting lean muscle growth (Choi *et al.*, 2023). Lower abdominal fat levels are desirable in broiler production, as they improve meat quality and consumer preference.

SBO also influences the composition of intramuscular fat, which affects meat texture and juiciness. A study by Ravindran *et al.* (2017) found that broilers on SBO-based diets had moderate intramuscular fat levels, enhancing meat tenderness without excessive fat accumulation. The balance between protein and energy in SBO diets plays a crucial role in optimizing these traits, ensuring that broiler meat remains both nutritious and palatable. Proper protein nutrition, including fatty acid from SBO, supports skeletal growth and bone mineralization (De Coca-Sinova *et al*., 2017). Strong skeletal structure is essential for broilers to support rapid weight gain and avoid processing defects such as broken bones during slaughter. Enzyme supplementation in SBO diets has been shown to improve calcium and phosphorus utilization, further enhancing bone integrity (Batal and Parsons, 2016).

Meat quality attributes such as colour, texture, and water-holding capacity are also influenced by SBO inclusion. Research by Zhang *et al*. (2022) indicates that SBO contributes to improved meat texture by enhancing protein deposition and reducing excessive connective tissue formation. Additionally, its high digestibility and amino acid balance support optimal muscle hydration, reducing drip loss and improving overall meat quality.

Excessive SBO levels without proper amino acid supplementation may lead to disproportionate muscle growth or increased carcass fat content (Ravindran *et al*., 2017). Therefore, proper diet formulation, including the addition of synthetic amino acids such as lysine and methionine, ensures balanced nutrient intake for ideal carcass development. The economic implications of SBO on carcass traits are also noteworthy. Since broiler meat yield and quality directly influence market value, incorporating SBO effectively in poultry diets can enhance profitability (Tahmisbi *et al*., 2024). The widespread availability and cost-effectiveness of SBO make it a preferred choice for poultry producers seeking to maximize carcass yield while maintaining production efficiency.

2.12 Impact of Soya Bean Oil on Bone Traits of Broilers

Soya bean oil (SBO), a rich source of unsaturated fatty acids, is frequently used in poultry diets to enhance energy density and improve nutrient absorption. Its inclusion in broiler chicken diets has shown notable effects on growth performance and bone development. Soya bean oil improves the absorption of fat-soluble vitamins, particularly vitamin D3, which plays a key role in calcium and phosphorus metabolism. These minerals are vital for proper bone formation and mineralization (Rafeeq *et al*., 2020). Improved vitamin D3 bioavailability enhances tibia ash content and bone strength in broilers. The inclusion of soya bean oil in broiler diets has been associated with increased tibia breaking strength and bone density**,** especially when diets are balanced for calcium and phosphorus. According to Zhao et al. (2020), broilers fed diets containing up to 6% SBO showed improved tibia strength compared to those on fat-free diet.

SBO contributes to energy balance, which is critical for optimal growth and skeletal development. Adequate energy allows for efficient protein and mineral utilization, thus supporting stronger and well-structured bones (Qamar *et al*., 2025). While soya bean oil itself does not harm bone traits, excessive inclusion without proper adjustment of other nutrients (especially minerals) can result in nutrient imbalances, potentially weakening bone quality. High energy intake without adequate calcium/phosphorus supplementation can reduce bone mineralization and increase the risk of skeletal disorders (Vorland, 2017).

One of the key factors influencing bone health in broilers is dietary protein quality and digestibility. SBO contains moderate levels of essential amino acids, particularly lysine and methionine, which play roles in collagen synthesis and bone matrix formation (Rath *et al*., 2017). Studies suggest that broilers fed SBO- based diets may exhibit similar or slightly improved bone development compared to those on diets with lower-quality protein sources, depending on inclusion levels and amino acid balance (Liu *et al*., 2019).

Calcium (Ca) and phosphorus (P) metabolism are central to bone mineralization, and SBO-contains phytates that can bind phosphorus and reduce its bioavailability (Couce *et al*., 2021). However, phytase enzyme supplementation has been shown to significantly enhance phosphorus digestibility in SBO-based diets, which can contribute to improved bone mineralization and skeletal strength (Cowieson *et al*., 2017). Bone density is an important measure of skeletal health. Some evidence indicates that inclusion of properly balanced SBO in broiler diets may support tibia and femur mineralization, particularly when phosphorus and calcium are adequately supplied and digestibility is optimized (Salim *et al*., 2022). Additionally, the mechanical properties of bones, such as breaking strength, are influenced by nutrient composition and digestibility. Research by Zhang *et al*. (2022) noted that broilers receiving diets with balanced amino acid profiles, including those based on SBO, had stronger tibias with enhanced resistance to fracture. Histological analyses also show that well-formulated SBO diets may support favorable bone microarchitecture, such as increased trabecular thickness and organized osteocyte structure (Kim *et al*., 2021).

While SBOM offers numerous benefits to bone health, its impact may vary based on dietary formulation and nutrient interactions. Excessive inclusion of SBO in broiler diets can lead to amino acid imbalances or reduced calcium absorption, potentially compromising skeletal integrity (Salim *et al*., 2022). Therefore, appropriate dietary formulation, including the supplementation of essential minerals and enzymes, is necessary to maximize the benefits of SBO for bone traits.

Comparative studies between SBO and alternative protein sources, such as fish meal and meat meal, have shown that SBO can be equally effective in supporting bone health when properly balanced with minerals (Jian *et al*., 2016). However, further research is needed to optimize SBO inclusion levels and evaluate its long-term effects on skeletal development.

2.13 Lipid Metabolism

Lipids are a highly concentrated source of energy, with more than twice the energy density of carbohydrates (Chandel, 2021). The synthesis of fatty acids from non-carbohydrate sources is very limited in broilers, especially in adipose tissue. A significant portion (80–85%) of the fatty acids stored in adipose tissue are derived from plasma lipids, which originate from either the diet or the liver. The liver plays a critical role by processing and assembling lipids into lipoproteins, which are then secreted into the bloodstream (Lal, 2023). Broilers have a limited ability to efficiently utilize dietary fats, particularly at a young age. The product of carbohydrate metabolism, acetyl-CoA, can be converted into fatty acids and stored as lipids, demonstrating the close link between the two pathways (Moffett, 2020).

Changes in the levels of protein, carbohydrates, and lipids in the diet significantly impact metabolic processes and overall performance. Adding emulsifiers to feed can improve fat utilization and digestion in broilers, potentially lowering costs (Chandel, 2021). Young birds have physiological limitations in their capacity to digest and use dietary fats effectively. Supplementing diets with nutrients like zinc can modulate lipid metabolism and improve performance, even under challenges like necrotic enteritis (Lal, 2023).

2.15 Maize Grains

Maize (*Zea mays* L.) is a major staple food grain throughout the world, particularly in Africa, Latin America and Asia, and a major feedstuff in developed countries. The maize grain has many food (grain, flour, syrup, oil etc) and non-food usages (cosmetics, adhesives, paints, varnishes). Maize starch and oil are also major products (Ecocrop, 2010). The maize grain is a major feed grain and a standard component of livestock diets where it is used as a source of energy. Other grains are typically compared to maize when their nutritional value is estimated. Many by-products of maize processing for flour (hominy feed, bran, germs, oil meal), starch (corn gluten feed, corn gluten meal) and alcohol/biofuel industries (distillers' dried grains and soluble) can be fed to animals.

2.16 Nutrient Composition of Maize

Maize grain is a globally significant cereal grain and a foundational food source, particularly in many parts of Africa, Lartin America and Asia (Erenstein, 2022). The composition of various nutrients in maize are tabulated in Table 2.5.

Table 2. 5: Nutrient Composition of Maize.

Nutrient	**Quantity**
Weight	100g
Energy	1651.08 KJ
Calories	390.76 kcal
Fat	4.38g
Protein	9.807g
Carbohydrate	73.85g
Fibre	8.35g
Water	10.56g

Source: Avedeweh (2015)

2.14 Carbohydrate Metabolism

Carbohydrate and lipid metabolism in broilers are central to energy production and growth, with carbohydrates (especially glucose) serving as the primary energy source, while lipids provide concentrated energy (Singh *et al*., 2017). These metabolic pathways are interconnected, as products of glucose metabolism, such as acetyl-CoA, can be converted into lipids for storage. Broiler metabolism is optimized by ensuring adequate dietary carbohydrates for immediate energy and by managing lipid intake and utilization, as young birds have limitations in efficiently digesting and utilizing fats. Glucose is the main energy source, converted into pyruvate, which then enters the citric acid cycle to produce large amounts of ATP through oxidative phosphorylation (Chaudhry, 2018). Dietary carbohydrates are essential for maintaining blood glucose levels, which are crucial for tissues that rely heavily on glucose. Low-carbohydrate diets can lead to low glucose levels, impacting performance and growth.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Location and Duration of the Study

The study was conducted at the Poultry section of the Department of Animal Science Education of the Akenten Appiah - Menka University of Skills Training and Entrepreneurial Development, Asante Mampong campus. Asante Mampong lies in the Transitional zone between the Guinea Savannah Zone of the North and the Tropical Rain Forest of the South of Ghana along the Kumasi-Ejura Road. The study lasted for two months. The study started in January and ended in March, 2025.

3.2 Dietary Treatments and Experimental Design

The composition of homogenized primary components (maize, wheat bran, soya bean meal, and fishmeal) was assessed and applied in creating four experimental diets (Table 3.1). The experimental design used for the experiment was completely randomized design (CRD). The treatment groups included: Treatment one (T1) – Conventional soya bean meal diet (Control diet) Treatment two (T2) – Full-fat Soya beans meal diet, Treatment three (T3) – Soya beans Oil diet, and Treatment four (T4) - Full-fat Soya bean meal + Conventional soya bean meal in starter and grower/finisher diets. The diets were formulated using the Concept 5-feed formulation program from Creative Formulation Concepts, LLC, based in Annopolis, MD. After formulation, the nutrient composition of the diets was determined through proximate chemical analysis using procedure according to AOAC (1990). Throughout the starter phase (d 0 to 28), grower- finisher phase (d28 to 56), water and diets were freely available ad libatum. In all phases, the diets were provided in mash form.

Table 3. 1: Composition and Calculated Analysis of Experimental Diet

	Starter Diet				Grower/Finisher Diet			
Ingredients	**T1**	**T2**	**T3**	**T4**	**T1**	**T2**	**T3**	**T4**
Maize grain	65	55	56.5	55.04	74	65	64.5	66.69
Soya bean meal	15	0	14	4	7.22	0	7.9	6
Wheat bran	1.49	18.31	8	8	2.52	5.5	8	7
Fish meal	16.28	17.16	17	14	14.42	9.5	14.5	12.57
Dicphosphate	0.98	0.8	0.8	0.8	0.65	0.9	0.7	1.1
Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Oyster shell	0.24	0.39	0.4	0.53	0.2	0.3	0.23	0.35
Full-fat soya bean	0	17.34	0	17	0	17	0	12.57
Soya bean oil	0	0	2.17	0	0	0	2.5	0
Mineral Premix	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100	100	100	100
Calculated Nutrient								
Protein	23	23	23.09	23.08	20.0	20.0	20.0	20.0
Calcium	1	1	1	1	0.87	0.84	0.84	0.82
Fat	4.21	7.05	6.35	6.74	4.65	8.5	6.76	7.10
Phosphorus	0.45	0.48	0.47	0.45	0.34	0.35	0.38	0.4
M.E (Kcal/kg)	3000	3000	3000	3000	2900	2900	2900	2900
Methionine	0.48	0.46	0.48	0.44	0.45	0.44	0.43	0.43
Lysine	1.37	1.37	1.38	1.32	1.26	1.23	1.21	1.20
Fibre	2.86	3.50	3.26	3.59	3.09	3.25	3.49	3.70

Premix contains the following per kilogram of diet: Fe100mg,Mn110mg, Cu 20mg,Zn100mg Se 0.2mg, Menadione 1.33mg, Co 0.6mg,Seno0.6mg,Retinal2000mg,Cholecalciferol2525mg, Atocopherol 25mg, Cobalamin 0.03mg, thiamin 0.83mg,Riboflavin 2 mg, Folic acid 0.33mg, Biotin 0.03, Pantothenic acid 3.75mg, Macin 23.3mg, pydoxine 1.33mg

3.3 Experimental Birds and Management

Two hundred (200) Ross 308-day-old chicks (unsexed) were raised in an open-sided deep litter housing system. The housing system was bedded with fresh softwood shavings (5 cm deep), and the chicks had *ad libitum* access to starter, grower, and finisher diets as well as water throughout the fifty-six-day experimental period. Upon arrival from the hatchery, chicks of comparable sizes were balanced by weight and randomly distributed among twenty floor pens (each measuring 2.4 m^2), with five replicate pens per treatment, accommodating ten birds each. Each pen was equipped with plastic feeding and watering troughs. Birds were introduced to twenty- four hours light during the brooding stage through to the Sixth week and then reduced to twelve hours light and twelve hours darkness till the eighth week of the study.

3.4 Data Collection

Data was collected on: growth performance, gut pH carcass characteristics, bone traits and economics of production.

3.4.1 Growth performance

Two week calculations were made for feed consumption, body weight, body weight gain, feed conversion ratio (feed: gain), and livability. Feed fed was subtracted from leftover to determine feed consumption. By dividing the total pen weight by the total number of birds in the pen, the body weight was calculated. The difference between the birds' final weight and their starting weight was used to compute gain. The FCR was computed by dividing amount consumed during the same period by weight gain. The number of birds presently in each pen was divided by the initial number of birds multiplied by 100 to determine livability. Throughout the study period, postmortem examinations were performed on deceased birds and the pens were checked twice a day for mortality. In order to account for mortality, feed intake and feed conversion ratio (feed intake divided by weight gain) were calculated.

3.4.2 Relative organ weight

The liver, breast meat, thigh, heart, and empty gizzard weight were taken from the sampled birds and weighed. Each part was expressed as percentage of live body weight (BW).

3.4.3 Bone traits

On days fifty-six post-hatch, the femur and tibiae bones were removed from the left leg of the sampled birds and used to assess bone weight, dimensions, and bone-breaking strength. The dimensions of the femur and tibia were measured, including length (mm) from the proximal end to the distal end and width (mm) at the medial region, using a digital caliper, and the femur and tibia bones of the two sampled birds were weighed (grams) after air drying for one week using an electronic scale (Mettler Toledo) and the result was express as a percentage of the live body weight. To determine breaking strength (BS), the flesh was removed manually from the femur and tibiae using a scalpel. Subsequently, the femur and tibiae underwent testing on a universal texture analyzer (Inspekt table50-1, Hegewald and Peschke, Meß- Germany) equipped with a 50 KN load cell and 3-point fixture bed, operating at a test speed of 10 points of data per second. The equipment was controlled by a BenQ computer (24 Inch IPS monitor) using Blue Hill 3 software.

3.5 Proximate Analysis of Experimental Diets

3.5.1 Crude protein determination

The crude protein content of the diets was determined using the AOAC (1990) procedure with a little modification. Protein determination was done in three stages thus digestion, distillation and titration.

Digestion stage

Two (2.0) grams of diet samples were put into digestion flasks and a half tablet of Selenium-based catalyst was added. 25 ml of concentrated Sulphuric acid was added to each of the flasks and shaken thoroughly to ensure complete soaking of the samples. The flasks were then placed on a digestion burner and heated slowly with intermittent shaking until a clear greenish solution was obtained (usually 1-hour period). The digested samples (digests) were allowed to cool and transferred into a 100 ml volumetric flask and made up to the mark with distilled water.

Distillation

Kjeldahl nitrogen distillation apparatus (TecatorTM Kjeltec System) was flushed out using distilled water for about 5 minutes. 25 ml of 4 % boric acid was measured into 250 ml conical flasks and two drops of mixed indicator were added. Each of the 100ml diluted digests was transferred into a Kjeldahl distillation tube and then 50ml of 40 % NaOH was added. The apparatus was switched into operation whereby steam was generated and the mixture was heated in a tube. This process liberated gaseous ammonia which was collected into the conical flask until 150ml of the distillate was obtained. The colour change observed in the conical flask was pink to bluish-green. A blank test was conducted without the test samples.

Titration

The distillates were titrated with 0.1N HCl solution. The end-point was noted during the titration which was from the bluish-green colour to colourless. The volume of HCl used (titre values) was then recorded after colour changes to pink by a drop.

Calculation;

Nitrogen (N) $=\frac{(1.4007\times 0.1\times Titre\ value)}{2}\times 10$ Crude protein = N × 6.25

3.5.2 Ash Determination

Two grams (2g) of diet samples were weighed into already cleaned and weighed crucibles in duplicate. The crucibles were placed in a furnace (Vecstar) preheated at 600°C for two hours (2hrs). The crucibles were removed, cooled, and reweighed. The masses of the crucibles and their contents were found by subtraction. The ash content was calculated by difference and expressed as a percentage of the initial weight of the sample.

3.5.3 Crude Fat Determination

2 g of diet samples were weighed and transferred into a paper thimble plugged at the opening with glass wool and placed into a thimble holder. Petroleum ether of volume 150ml was measured into a previously dried and weighed 250ml round-bottom flask and this was assembled with the thimble holder and its contents. The Quick fit condenser was connected to the Soxhlet Extractor and refluxed for sixteen hours (16hr) on low heat on a heating

mantle. After extraction the flask containing the fat was dried at 105°C in an oven for 30 minutes, cooled in a desiccator and the weight of the fat collected was determined and expressed as a percentage of crude fat (AOAC, 1990).

3.5.4 Crude Fibre Determination

The samples after the determination of the crude fat were weighed and transferred into a 500 ml Erlenmeyer flask and few chips were added and 200 ml of 1.25 % sulphuric acid was added to each of the samples. The flask was then set on a hot plate and connected to a condenser. The content was timed at the onset of boiling. At the end of the thirty minutes, the flask was removed and the contents filtered through a linen cloth in a funnel. Boiling water was used to wash the content till the acid was removed. The distillate was discarded and the residue was placed back into the Erlenmeyer flask containing the chips using a spatula 200 ml of 1.25 % NaOH was added and flask reconnected to the condenser. The content was left to boil for thirty minutes after which the flask was disconnected and the content filtered using linen cloth. The content was washed with boiling water till the base was completely removed and then finally washed with ethanol to break any lumps. The residue was transferred into a porcelain crucible and dried in an oven for 2s hours at 130°C. The weight of the dried residue now composed of the crude fibre and minerals was recorded and then placed in the furnace for 30 minutes to burn off the organic material (crude fibre) leaving the inorganic (minerals). The content after ashing was allowed to cool after which the weight was taken. The crude fibre was obtained by a subtraction of the weight of the ash from the weight of the dried residue before ashing.

3.5.5 Metabolisable Energy Determination

Metabolisable energy (ME kcal/kg) was calculated according to the formula derived by Pauzenga(1985), ME kcal/kg=(37*%CP)+(81.8*%EE)+35*NFE) . Where

ME=Metabolisable Energy, CP=Crude protein, EE= Ether Extract and NFE= Nitrogen Free Extract

3.5.6 Gastrointestinal pH

As described by Zanu *et al.* (2023), two birds per replicate pen were sampled and through cervical head dislocation the sampled birds were killed. The birds will be dissected, and the pH of the crop, proventriculus, gizzard, duodenum, jejunum, ileum, and caeca will be measured using a pH tester (Hanna Instruments, UK) by directly inserting the pointed tip into the digesta in the lumen of the proximal end of each segment of the sampled bird, making sure the pH electrode does not touch the walls. The probe were cleaned with distilled water once all of the readings for each bird had been obtained. The next step was calculating the mean of the two readings for each tract section of the two sampled birds.

3.5.7 Bone Breaking Strength

To determine breaking strength (BS), the flesh was removed manually from the femur and tibiae using a scalpel. Subsequently, the femur and tibia will undergo testing on a universal texture analyzer (Inspekt table50-1, Hegewald and Peschke, Meß- Germany) equipped with a 50 KN load cell and 3-point fixture bed, operating at a test speed of 10 points of data per second. The equipment was controlled by a BenQ computer (24 Inch IPS monitor) using Blue Hill 3 software.

3.5.8 Cost benefit analysis of birds

The cost of feed per kg for each of the experimental diets was determined based on the usual market prices of the ingredients at the time of the experiment. The cost of the conventional feed in the diet was determined using the price per kilogram of conventional feed, cost of feed per replicate, cost per kilogram body weight gain, selling price per kilogram of chicken, selling price of broilers and profit on feed. The price per kilogram cost of feed will be determined by multiplying the quantity of each ingredient by the unit cost of the ingredients to get the cost of ingredients. The cost of ingredients was summed up to obtain the total feed cost. Then, the total feed cost was divided by one hundred to obtain the per kilogram cost of feed. The cost of feed per replicate was calculated by multiplying per kilogram cost of feed by the total feed consumed per replicate. The cost per kilogram body weight gain was determined by dividing the cost per bird by kilogram weight gain.

The current selling price per kilogram of chicken was used. The selling price of a bird was determined by multiplying the per kilogram selling price of broilers by the kilogram body weight gain. The profit on feed was calculated by subtracting the cost of feed from the selling price of a bird. The data was subjected to analysis.

3.5.9 Organ weight

The heart, liver, empty gizzard, breast meat and thigh was taken from the sampled birds used for the determination of gut pH and weighed. Each part will be expressed as a percentage of live.

3.6 Statistical Analysis of Data

To evaluate the effect of partial replacement of maize with soya bean oil or full fat soya bean on Ross 308 broiler chicken data were analyzed as a completely randomized design (CRD) using the General Linear Model (GLM) procedure of the Minitab 20.3 statistical software. Tukey's means separation test was used to make comparisons between treatment means at probability $P<0.05$.

CHAPTER FOUR: RESULTS

4.1 Nutrient Composition of Full-Fat Soya Bean Meal

The results of the proximate analysis of the full-fat soya bean meal (FFSBM) gave the following components; 5.35 % 9.63 %, 7.34 %, 34.15 %, 9.83 %, 7.90 % and 33.14 % for, moisture, ash, crude fat, crude protein, crude fibre and nitrogen free extract respectively (Table 4.1). The test sample's metabolisable energy was 3227.54 Kcal/kg.

Table 4. 1: Nutrient composition of full-fat soya bean meal

Nutrient Composition	%
Moisture content	5.35
Ash content	9.63
Crude protein	34.15
Crude fat	9.83
Crude fibre	7.90
Nitrogen free extract	33.14
Metabolisable energy (kcal/kg)	3227.54

4.2 Nutrient Composition of Experimental Diets

The proximate analysis of the experimental diets, as presented in Table 4.2, revealed notable variations in nutrient composition across both the starter and grower/finisher phases. Diets formulated with full-fat soya bean (T2) and soya bean oil (T3) generally exhibited higher crude protein levels compared to the control (T1), particularly during the starter phase. Crude fat content was highest in the diet combining conventional and full-fat soya bean (T4) across both feeding phases. However, soya bean oil-based diets (T3) recorded relatively lower metabolisable energy values, especially in the starter phase.

Moisture content was highest in T3 during both feeding phases. Ash content, representing mineral composition, was notably high in T3 diets but declined in T4 during the grower phase, while crude fibre content was highest in T3 and T1 diets. Nitrogen-free extract (NFE), was most abundant in the control diet (T1). Overall, the T4 diet consistently provided the highest metabolisable energy while T3 diets, despite oil inclusion, were relatively less energy-efficient and higher in moisture.

Table 4. 2: Nutrient Composition of Experimental Diets

Analyzed Nutrient Composition (%)	**Starter Diets**				**Grower/Finisher Diets**			
	T1	**T2**	**T3**	**T4**	**T1**	**T2**	**T3**	**T4**
Moisture content	8.30	8.18	9.02	8.06	8.01	8.39	10.17	9.81
Ash content	**17.25**	**14.64**	**19.45**	**16.85**	**17.52**	**17.80**	**21.49**	**13.53**
Crude protein	**17.51**	**20.58**	**20.14**	**19.26**	**18.83**	**19.26**	**19.70**	**19.48**
Crude fat	9.32	8.76	8.29	10.09	9.53	7.14	10.96	11.14
Crude fibre	4.79	7.72	8.57	5.86	**9.38**	**8.18**	**6.67**	**6.37**
Nitrogen free extract	42.83	40.12	34.53	39.88	36.73	39.23	31.01	39.67
Metabolisable energy kcal/kg	2909	2882	**2632**	2934	2762	2670	2711	3021

T1= control diet (conventional soya bean), T2= Full-fat soya bean diet, T3 = Soya bean oil diet, and T4 = Conventional soya bean + full fat soya bean diet.

Metabolisable energy (MEkal/kg) was calculated according to the formula derived by Pauzenga (1985: MEkcal/kg= (37%CP)+(81.8*%EE)+35*NFE)*

Where: CP=crude protein, CF=crude fibre, EE=ether extract, NFE= nitrogen free extract, DM=dry matter, MC =moisture content

4.3 Effect of Partial Replacement of Maize with Full Fat Soya Beans or Soya Bean oil on the Growth Performance of Broiler Chickens at d 14

The results in Table 4.3 show that there were no statistically significant differences (P > 0.05) among the treatment groups for all measured parameters, including body weight (BW), body weight gain (BWG), feed intake, feed conversion ratio (FCR), and livability during the starter phase (day 0–14). Although numerical differences were observed such as the highest BW (201.4 g) and feed intake (283.8 g) in T3 (soya bean oil diet), and the lowest (efficient) FCR (1.900) in T2 (full-fat soya bean diet) these variations were not significant. Livability remained high across all treatments, ranging from 98 % to 100 %.

Table 4. 3: Effect of Partial Replacement of Maize with Full Fat Soya bean or Soya bean Oil on the Growth Performance of Ross 308 Broiler Chicken at D 0-14

Treatment	BW(g)	BW Gain(g)	Feed Intake(g)	FCR (g)	Livability (%)
T1	146.8	158.0	256.0	1.977	100.0
T2	187.0	148.0	235.0	1.900	100.0
T3	201.4	163.4	283.8	2.053	98.00
T4	188.1	152.1	251.3	1.950	98.00
SEM	24.80	18.30	23.80	0.114	1.410
P-value	0.459	0.937	0.552	0.817	0.585

^{abc}*Means with different superscripts on the same column are Significantly different (P < 0.05), T1= control diet (conventional soya bean), T2 = Full-fat soya bean diet, T3 = Soya bean oil diet, T4 = Conventional soya bean + full fat soya bean diet, BW=body weight, and FCRc= corrected feed conversion ratio.*

4.4 Effect of Partial Replacement of Maize with Full Fat Soya Beans or Soya Bean oil on the Growth Performance of Ross 308 Broiler Chickens at d 28

According to results in Table 4.4, feed intake differed significantly (P = 0.003) among the treatment groups, with T2 (full-fat soya bean diet) recording the lowest intake (938.0 g), while T1 (control), T3 (soya bean oil diet), and T4 (conventional + full-fat soya bean diet) had significantly higher and similar feed intake values. No significant differences (P > 0.05) were observed in body weight, body weight gain, feed conversion ratio (FCR), or livability across treatments. Body weight ranged from 534.0 g (T2) to 641.0 g (T1), and FCR ranged from 1.966 (T2) to 2.375 (T3). Livability was high across all treatments, ranging from 98 % to 100 %.

Table 4. 4: Effect of partial replacement of maize with full fat soya bean or soya bean oil on the growth performance of Ross 308 broiler chicken at d 0-28

Treatment	BW(g)	BW Gain(g)	Feed Intake(g)	FCR(g)	Livability (%)
T1	641.0	570.0	1303.0^{a}	2.304	100.0
T2	534.0	495.0	938.0^{b}	1.966	100.0
T3	615.0	577.0	1366.9^{a}	2.375	98.00
T4	637.2	601.2	1303.0^{a}	2.175	98.00
SEM	33.60	40.70	74.40	0.136	1.410
P –value	0.127	0.318	0.003	0.196	0.585

^{abc}*Means with different superscripts on the same column are Significantly different ($P < 0.05$), T1= control diet (conventional soya bean), T2 = Full-fat soya bean diet, T3 = Soya bean oil diet, T4 = Conventional soya bean + full fat soya bean diet, BW=body weight, and FCRc= corrected feed conversion ratio.*

4.5 Effect of Partial Replacement of Maize with Full Fat Soya beans or Soya Bean Oil on the Growth Performance of Ross 308 Broiler Chickens at d 42

The results in Table 4.5 show that at day 42, there were significant differences ($P < 0.05$) among the treatment groups for body weight (BW), body weight gain (BWG), and feed intake. T2 (full-fat soya bean diet) recorded the lowest values for BW (763.0 g), BWG (724.0 g), and feed intake (1887 g), all of which were significantly lower than those observed in T1 (control), T3 (soya bean oil diet), and T4 (conventional + full-fat soya bean diet). However, no significant differences ($P > 0.05$) were found for feed conversion ratio (FCR) and livability among the treatments. FCR values ranged from 2.391 (T3) to 2.723 (T4), while livability remained high across treatments, ranging from 98 % to 100 %.

Table 4. 5: Effect of Partial Replacement of Maize with Full Fat Soya Beans or Soya bean Oil on the Growth Performance of Ross 308 Broiler Chicken at D 42

Treatment	BW(g)	BW Gain(g)	Feed Intake(g)	FCR(g)	Livability (%)
T1	1141^{a}	1105^{a}	2641^{a}	2.399	100.0
T2	763.0^{b}	724.0^{b}	1887^{b}	2.643	100.0
T3	1069^{a}	1031^{a}	2443^{ab}	2.391	98.00
T4	957.8^{a}	921.8^{a}	2508^{ab}	2.723	98.00
SEM	47.50	47.60	155	0.194	1.410
P-VAL	0.000	0.000	0.017	0.533	0.585

^{abc}*Means with different super scripts on the same column are Significantly different ($P < 0.05$), T1= control diet (conventional soya bean), T2 = Full-fat soya bean diet, T3 = Soya bean oil diet, T4 = Conventional soya bean + full fat soya bean diet, BW=body weight, and FCRc= corrected feed conversion ratio.*

4.6 Effect of Partial Replacement of Maize with Full Fat Soya Beans or Soya Bean oil on the Growth Performance of Ross 308 Broiler Chickens at d 49

At day 49, broilers fed the control diet (T1) showed significantly (P < 0.05) higher body weight and weight gain compared to those fed full fat soya bean diet(T2), which recorded the lowest values for both parameters, while birds on the soy bean oil diet (T3) and the conventional soya bean + full-fat soya bean combination diet (T4) had intermediate values. Feed intake was significantly (P < 0.05) higher in T1 and T3 compared to T2, with T4 not differing significantly from either. Feed conversion ratio (FCR) and livability were not significantly affected by the dietary treatments (P > 0.05).(Table 4.6)

Table 4. 6: Effect of Partial Replacement of Maize with Full Fat Soya Beans or Soya Bean Oil on the Growth Performance of Ross 308 Broiler Chicken at D 49

Treatment	BW(g)	BW Gain(g)	Feed Intake(g)	FCR(g)	Livability (%)
T1	1387^{a}	1351^{a}	3346^{a}	2.479	100.0
T2	946^{c}	907^{c}	2562^{b}	2.831	100.0
T3	1278^{ab}	1240^{ab}	3178^{ab}	2.563	98.00
T4	1189^{b}	1153^{b}	3195^{ab}	2.784	98.00
SEM	32.10	32.10	160.0	0.161	1.410
P-value	0.000	0.000	0.015	0.372	0.585

Means with different superscripts on the same column are Significantly different (P < 0.05), T1= control diet (conventional soya bean), T2 = Full-fat soya bean diet, T3 = Soya bean oil diet, T4 = Conventional soya bean + full fat soya bean diet, BW=body weight, and FCRc= corrected feed conversion ratio.

4.7 Effect of Partial Replacement of Maize with Full Fat Soya Beans or Soya Bean Oil on the Growth Performance of Ross 308 Broiler Chickens at d 56

At d 56, there were significant differences ($P < 0.05$) among treatments for body weight (BW), body weight gain (BWG), feed intake, and corrected feed conversion ratio (FCR), while livability remained unaffected ($P > 0.05$). T2 (full-fat soya bean diet) recorded significantly lower BW (1178 g), BWG (1139 g), and feed intake (3798 g) compared to the other treatments. T1 (control), T3 (soya bean oil diet), and T4 (conventional + full-fat soya bean diet) showed significantly higher BW and BWG, with T1 and T4 also showing the highest feed intake. FCR was highest in T2 (3.338), and lowest in T1 (2.582). Livability remained high across all treatments, ranging from 98 % to 100 % (Table 4.7).

Table 4. 7: Effect of Partial Replacement of Maize with Full Fat Soya beans or Soya Bean Oil on the Growth Performance of Ross 308 Broiler Chicken at D 56

Treatment	BW(g)	BW Gain(g)	Feed Intake(g)	FCRc	Livability (%)
T1	1699^{a}	1663^{a}	4611^{a}	2.582^{b}	100.0
T2	1178^{b}	1139^{b}	3798^{b}	3.338^{a}	100.0
T3	1519^{a}	1481^{a}	4330^{ab}	2.637^{ab}	98.0
T4	1582^{a}	1546^{a}	4589^{a}	2.970^{ab}	98.00
SEM	56.40	56.5	185	0.128	1.410
P-value	0.000	0.000	0.0230	0.045	0.585

^{abc}Means with different superscripts on the same column are Significantly different ($P < 0.05$), T1= control diet (conventional soya bean), T2 = Full-fat soya bean diet, T3 = Soya bean oil diet, T4 = Conventional soya bean + full fat soya bean diet, BW=body weight, and FCRc= corrected feed conversion ratio.

4.8 Effect of Partial Replacement of Maize with Full Fat Soya Beans or Soya Bean Oil on the Gut pH of Ross 308 Broiler Chickens

The effect of partial replacement of maize with full-fat soya beans and soya bean oil on gut pH in broiler chickens revealed no statistically significant differences ($P > 0.05$) across all gut sections as shown in Table 4.8. In the crop, the highest pH was observed in birds fed the soya bean oil diet (T3 = 4.902), while the lowest was in birds fed the full- fat soya bean diet (T2 = 4.529. In the proventriculus, birds fed the combination of conventional and full-fat soya bean (T4) had the highest pH (1.517), and those on the control diet (T1) had the lowest (1.227). For the gizzard, pH ranged from 1.600 (T4) to 1.840 (T1), with the control group having the highest value. In the duodenum, pH values were very similar across treatments, ranging from 4.552 (T2) to 4.703 (T4). In the jejunum, the control diet (T1) again showed the highest pH (5.694), and soya bean oil group (T3) the lowest (5.595). In the ileum, the most notable numerical difference was observed. Birds on the full -fat soya bean diet (T2) had the highest pH (6.420), while those on the control diet (T1) had the lowest (5.893). Although not statistically significant ($P = 0.189$), this is the largest observed numerical shift. Lastly, in the caeca, pH ranged from 6.735 (T1) to 6.872 (T2).

Table 4. 8: Effect of Partial Replacement of Maize with Full Fat Soya beans or Soya Bean Oil on the Gut pH Of Ross 308 Broiler Chickens

Treatment	Crop	Proventriculus	Gizzard	Duodenum	Jejunum	Ileum	Caeca
T1	4.801	1.227	1.840	4.569	5.694	5.893	6.735
T2	4.529	1.460	1.759	4.552	5.658	6.420	6.872
T3	4.902	1.454	1.770	4.653	5.595	6.370	6.853
T4	4.623	1.517	1.600	4.703	5.642	6.377	6.825
SEM	0.179	0.196	7.910	0.168	0.129	0.186	0.096
P-value	0.467	0.735	0.416	0.909	0.958	0.189	0.756

^{abc} *Means with different superscripts on the same column are Significantly different (P < 0.05), , T1= control diet (conventional soya bean), T2 = Full-fat soya bean diet, T3 = Soya bean oil diet, and T4 = Conventional soya bean + full fat soya bean diet.*

4.9 Effect of Partial Replacement of Maize with Full Fat Soya Beans or Soya Bean Oil on the Carcass Traits (% BW) of Ross 308 Broiler Chickens

The partial replacement of maize with full-fat soya beans and soya bean oil in the diets of broiler chickens did not significantly (P > 0.05) influence the relative weights of the heart, liver, breast, thigh, and spleen as percentages of body weight (Table 4.9). However, significant differences were observed in the gizzard and fat pad percentages (P = 0.014 and P = 0.000, respectively). The gizzard weight was highest in birds fed full fat-soya bean diet

(T2), significantly differing from those on the soya bean oil diet (T3), which had the lowest value. For fat pad percentage, birds on the soya bean oil diet (T3) had the highest value, significantly greater than those on the full fat soya bean diet (T2) and the combined soya bean diets (T4), while the control diet (T1) had an intermediate value.

Table 4. 9: Effect of Partial Replacement of Maize with Full Fat Soya Beans or Soya Bean Oil on the Carcass Traits (% BW) of Ross 308 Broiler Chickens

Treatment	**Heart**	**Liver**	**Gizzard**	**Breast**	**Thigh**	**Spleen**	**Fat pad**
T1	0.701	2.030	2.003^{sb}	3.759	9.522	0.118	0.011^{ab}
T2	0.824	2.070	2.323^{a}	3.607	9.448	0.010	0.009^{bc}
T3	0.795	4.010	1.897^{b}	3.906	9.660	0.143	0.012^{a}
T4	0.798	2.050	2.232^{ab}	3.967	9.486	0.125	0.007^{c}
SEM	0.032	1.010	0.090	0.199	0.163	0.018	0.001
P-value	0.076	0.444	0.014	0.592	0.808	0.411	0.000

^{abc}Means with different superscripts on the same column are Significantly different ($P < 0.05$), T1= control diet (conventional soya bean), T2 = Full-fat soya bean diet, T3 = Soya bean oil diet, and T4 = Conventional soya bean + full fat soya bean diet.

4.10 Effect of Partial Replacement of Maize with Full Fat Soya beans or Soya bean oil on the Bone Traits of Ross 308 Broiler Chickens

From Table 4.10, there was a significant ($P < 0.05$) effect of the treatment on tibia length, with birds fed the control diet (T1), full-fat soya bean diet (T2), and the combined soya bean diet (T4) exhibiting significantly longer tibiae than those on the soya bean oil diet (T3), while no significant ($P > 0.05$) differences were observed among treatments for femur length, tibia diameter, femur diameter, tibia and femur breaking strength.

Table 4. 10: Effect of Partial Replacement of Maize with Full Fat Soya Beans or Soya Bean Oil on the Bone Traits of Ross 308 Broiler Chickens on Day 56

Treatment	Tibia length(mm)	Femur Length(mm)	Tibia Diameter(mm)	Femur Diameter(mm)	Tibia BS	Femur BS
T1	98.80^{a}	71.62	6.445	7.368	134.3	209.6
T2	98.14^{a}	69.32	6.201	6.793	152.0	196.2
T3	92.14^{b}	72.29	6.583	7.204	188.2	207.7
T4	96.11^{a}	71.28	6.290	7.124	142.9	200.7
SEM	0.898	1.060	0.194	0.201	15.60	18.20
P-Value	0.000	0.267	0.532	0.267	0.115	0.949

^{abc}*Means with different superscripts on the same column are Significantly different (P < 0.05T1= control diet (conventional soya bean), T2 = Full-fat soya bean diet, T3 = Soya bean oil diet, T4 = Conventional soya bean + full fat soya bean diet, and BS=Breaking strength.*

4.11 Effect of Partial Replacement of Maize with Full Fat Soya beans or Soya Bean Oil on the Economic Efficiency of Ross 308 Broiler Chickens

The economic analysis revealed statistically significant differences (P < 0.05) in several economic parameters among the dietary treatments, including Price of bird at day 56, Profit, Feed cost to profit ratio, Price-to-feed cost ratio, and Performance Efficiency Index (PEI), while Total feed cost and cost per kg feed did not differ significantly (P > 0.05).

The Price of birds at day 56 was significantly higher (P = 0.000) in T1 (₵59.47), T3 (₵53.15), and T4 (₵55.36) compared to T2 (₵41.23), which recorded the lowest value. Birds in T1, T3, and T4 had statistically similar price values. Although the Total Feed Cost did not differ significantly among treatments (P = 0.458), numerically, T1 had the highest cost (₵42.88), followed by T3 (₵40.96), T4 (₵39.90), and T2 (₵38.96). Profit at day 56 differed significantly (P = 0.000), with T1 (₵16.59), T3 (₵12.20), and T4 (₵15.46) yielding significantly higher profits than T2 (₵2.27). The Feed cost to profit ratio showed significant differences (P = 0.001). T1 (0.3887), T3 (0.2994), and T4 (0.3939) recorded higher ratios compared to T2 (0.0704), which was significantly lower.

Similarly, the Price-to-feed cost ratio was significantly different (P = 0.001). T1 (1.3887), T3 (1.2994), and T4 (1.3939) had comparable values and were significantly higher than T2 (1.0704), which was statistically different.

Finally, the Performance Efficiency Index (PEI) varied significantly among treatments (P = 0.000). T1 had the highest PEI value (126.1), followed by T3 (94.84) and T4 (93.52), which were statistically similar, while T2 recorded the lowest PEI (67.55) and was significantly different from the other treatment diets.

Table 4. 11: Effect of Partial Replacement of Maize with Full Fat Soya bean or Soya bean Oil on Economic Efficiency of Broiler Chickens

Treatment	Cost per kg feed	Price of bird d56 ℂ	Total Feed Cost d56 ℂ	Profit d56 ℂ	Profit d56: Feed cost ℂ	Price/Wt, ℂ Feed Cost
T1	7.2631	59.47^a	42.88	16.59^a	0.3887^a	1.3887^a
T2	7.2364	41.23^b	38.96	2.27^b	0.0704^b	1.0704^b
T3	7.1560	53.15^a	40.96	12.20^a	0.2994^a	1.2994^a
T4	7.2631	55.36^a	39.90	15.46a	0.3939^a	1.3939^a
SEM	0.0414	1.970	1.760	1.890	0.051	0.051
P-value	0.135	0.000	0.458	0.000	0.001	0.001

^{abc}*Means with different superscripts on the same column are Significantly different ($P < 0.05$), T1= control diet (conventional soya bean), T2 = Full-fat soya bean diet, T3 = Soya bean oil diet, T4 = Conventional soya bean + full fat soya bean die.*

CHAPTER FIVE: DISCUSSION

5.1 Nutrient Composition of Full –Fat Soya Bean

Analysis of the full –fat soya bean (FFSB) used in this study revealed 34.15% crude protein 9.83% crude fibre, 7.34% crude fat, and 33.14% nitrogen –free extract (NFE), with a calculated metabolisable energy (ME)of 3144kcal/kg, confirming its value as an energy-rich feed ingredient. The crude protein level indicates that FFB is a reliable protein source. Km et al. (2021) reported that crude protein value ranging from 33% to 38% in full –fat soya bean, supporting their potential as alternative to soya bean meal when properly heat-processed to deactivate anti-nutritional factors like trypsin inhibitors. Similarly, Oduguwa et al. (2014) found comparable protein content in heat-treated full-fat soya bean, further validating its implication in poultry diet. the crude fat level of 7.3% is noteworthy, as it play vital role in increasing the energy concentration of the diet.

Dietary fat not only boosts caloric supply but also facilitates the absorption of fat-soluble vitamin whiles minimizing feed dustiness (Sibbald, 1986). Although this value is slightly lower than 10-18% ether extract range reported by Olukosi et al. (2008) for full-fat soya bean under different processing method, it still contributed positively to the metabolisable energy (ME), which was calculated at 3144kcal/kg. This figure is below NRC (1994) value estimates of 3200-3400 kcal/kg for full- fat soya bean, suggesting that the sample analysed was effectively process and preserved much of its inherent oil content. The nitrogen-free extract (33.14%) and crude fibre (9.83%) values illustrate the carbohydrate profile of the FFSB. The fibre level, though higher than that of conventional soya bean meal (<5% CF), is typical of full-fat forms due to hull retention. Elevated fibre can reduce nutrient digestibility, but appropriate inclusion levels help maintain a balance between energy and fibre (Adeyemi and Ajayi, 2020). The NFE component, composed of soluble carbohydrates and starches, contribution readily available energy to support rapid broiler growth (Rostagno et al., 2017). Moisture (5.35%) and ash (9.63%) content were within acceptable feed standard; low moisture promotes safe storage by limiting microbial growth, whiles the moderately high ash may result from mineral –rich soil or hull retention. Since excessive ash can reduce dietary nutrient density, its level should be carefully managed (Kellem and church, 2010).

5.2 Nutrient Composition of the Experimental Diet

The proximate composition of the experimental diet indicated that though the analyzed crude protein and crude fibre were slightly lower than the formulated level, the diet were similar.

5.3 Effect of Partial Replacement of Maize with Full –Fat Soya Bean or Soya Oil on Growth Performance of Broiler 308 Broiler Chickens at d14

The study showed that partial replacement of maize with full –fat soya bean (FFSB) or soya oil influence growth performance differently across production stages during the starter phase (d0-d14), no significant differences were found in body weight, body weight gain, feed intake, feed conversion ratio, or livability, although numerical variation indicated trend. Birds on soya bean oil diet recorded the highest BW and feed intake, whiles those on FFSB diet had the lowest FCR, consistent with Batal and Parson (2004), who highlighted improve early nutrient digestibility with oil inclusion.

On day 28, only feed intake differed significantly with FFSB group consuming less, likely due to higher diet energy density causing early satiety (Leeson and Summers, 2001). Despite reduced intake, BW and BWG were unaffected, suggesting efficient nutrient utilization.

At d42, birds on FFSB shown lower BW, BWG and feed intake, suggesting cumulative effects of reduced palatability or anti-nutritional factor (Sundu et al., 2006). By d49, performance differences widened, with the control group outperforming soya bean oil diet in BW and BWG, possibly due to poor oil utilization or nutrient imbalance (Zhang et al., 2011). FFSB and mixed diet performed moderately.

At d56, significant depression in BW, BWG, FI and FCR in the FFSB group reinforced its long-term nutritional in- balance and anti- nutritional impact (OlomU., 2011). Livability remained high (98 -100%) across treatment indicating diet safety.

5.4 Effect of Partial Replacement of Maize with Full Fat Soya Bean or Soya Oil on Gut pH

Partial replacement of maize with FFSB or soya oil did not significantly alter gut pH, though numerical variation occurred in certain segment. in the crop, the highest pH was recorded in FFSB-fed birds, whiles soya bean oil diet yielded the lowest, consistent with Syihus (2011), who reported that fat-induced alterations in fermentation and gastric emptying. proventriculus and gizzard pH values remain acidic (1.2-1.8), reflecting normal gastric function, with slight diet-related variation likely due to protein and fat buffering (Rayindran et al., 2006)

Small intestine pH remain moderately alkaline, consistent with neutralization by pancreatic and bile secretion. Only minor difference were observed in the duodenum and jejumum, while ileal pH was highest in soya bean oil fed birds, suggesting reduce fermentation or bile salt-related effect (Hetland et al.,2004). Caecal pH remained stable across treatments (6.7-6.9) typical of high gut fermentation and consistent with Torok et al. (2011), indicating minimal impact of dietary fat on microbial activity.

5.5 Effects of Partial Replacement of Maize with Full Fat Soya Bean or Soya Oil on Carcass Traits

Maize replacement with FFSB or soya bean oil did not significantly affect relative weight of most carcass components (heart, liver, breast, thigh, and spleen). These results align with Fan et al. (2008) and Rayindran et al. (2016), who found out that soya bean –based ingredient support growth without altering organ development when diet is isoenergetic and isonitrogenous.

However, significant differences were observed in gizzard and fat weight. Birds on soya bean oil diet showed large fat pad due poor utilization of energy. This is in agreement with a report made by Bello et al. (2023) who found out that excess energy is converted to fat after maintenance and production. FFSB-fed birds showed the largest gizzard weight likely due to had dietary fibre availability compared to the soya bean oil diet (Zhao et al., 2009, Zhang et al., 2011) intermediate value in control and mixed diet reinforced the role of form and availability in lipid deposition (Zeng et al., 2015).

These indigestible fractions stimulate gizzard activity and muscular development, enhancing its relative size compared to diets containing extracted oils. The fibrous matrix and non-starch polysaccharides present in full-fat soya bean exert a mechanical effect on the gastrointestinal tract, thereby promoting hypertrophy of the gizzard (Ravindran, 2013; Choct, 2018).

5.6 Effects of Partial Replacement of Maize with Full Fat Soya Bean or Soya Oil on Bone Traits

The diets significantly influenced tibia length but not femur length, bone diameter or breaking strength, birds on the control, FFSB, and mixed diet had longer tibia compared to those on soya bean oil diet the diet are balance in protein – energy profile alongside potential bioactive benefit for mineralization (Wei et al., 2013). Reduced tibia length in the soya bean oil group may reflect imbalances in protein – energy ratio or mineral metabolism linked to rapid energy released from free oils (Fritts and Waldroup, 2003; Korver, 2005). The reduced tibia length in T3 is primary due its effect on nutrient partitioning and bone mineralization. This is in compliance with Rafeeq *et al*., 2020). et al. (2020) who reported that dietary oil increase the density of feed, it may alter calcium and phosphorus utilization, which are essential for proper skeletal development. Excess dietary fat can also interfere with some vitamin metabolism, thereby reduce mineral absorption efficiency and ultimately compromising tibia growth and mineral deposition (Olukosi et al., 2019) reported.

5.7 Effects of Partial Replacement of Maize with Full Fat Soya Bean or Soya Oil on Economic Efficiency

Economic outcomes were strongly influenced by diet. Birds on conventional soya bean (T1) soya bean oil (T3), and combined diet (T4) achieved higher market price and profit compare to those on FFSB diet (T2). This agrees with Tijani et al. (2016) and Oladokum et al. (2018), who linked improved growth and carcass traits to higher economic returns.

Feed cost were comparable across treatments, indicating maize substitution with soya bean derivative did not raise cost, echoing Ojebiyi et al. (2014). Profit and performance efficiency index (PEI) were highest in T1, followed by T3 and T4, reflecting better growth and feed efficiency (Attia et al., 215).T2 ‘s lower profit highlighted that feed cost alone is less important than market weight in determining returns (Onu and Madubuike, 2012). Overall, soya bean oil and combined diet improved cost efficiency, while sole FFSB use was less profitable due to performance limitation, reinforcing the need for balanced formulation (Adeniji and Jimoh, 2007).

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

From the results of the 8-week trial, the following conclusions were made:

Partial replacement of maize with full –fat soya bean (FFSB) or soya bean oil (SO) has varied effects on broiler growth across the production cycle. Whiles performance was similar across treatment during the starter phase (day 14), differences emerged from day 28 onward. Birds fed FFSB consistently exhibited lower feed intake, body weight, and body weight gain, especially by day 42, 49, and 56, showing reduced growth with advancing age. In contrast, the control diet yielded the best growth while soya beans oil showed intermediate performance.

Gut pH values were not significantly affected, suggesting that substituting maize with soya bean products does not disturb gastrointestinal pH balance.

Carcass traits were influenced, FFSB diet increasing gizzard weight whereas soya bean oil diet led to higher abdominal fat deposition.

Bone traits showed that only tibia length was affected, being shorter in birds on soya bean oil diet. Femur length, bone diameters, and breaking strength remained unaffected.

Soya bean oil diet and mixed diet (regular soya bean and full-fat soya bean) diets resulted in increased price per bird, profit, and performance efficiency index (PEI) compared to birds on full-fat soya bean diet.

6.2 Recommendations

Based on the findings, the following recommendations are made

1. For optimal broiler performance, particularly at the starter phase, partial inclusion or blending with conventional soya beans meal is recommended.
2. Soya bean oil should be incorporated carefully, as it may increase fat deposition while reducing tibia length.
3. Using balanced blend FFSB, soya bean oil, and conventional soya bean by reducing maize inclusion in poultry diet is advisable to optimize growth, carcass quality, skeletal development, and fat deposition in broilers.

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APPENDICES

Week 2

Appendix A1: Calculation of Livability d 0-14

$count\ d14 \div count\ d0 \times 100$

Appendix A2: Calculation of Body weight d 0-14

$Pen\ weight\ d14 \div count\ d14$

Appendix A3: Calculation of Gain d 0-14

$(Pen\ weight\ d14 \div count\ d14) - (Initial\ weight\ d0 \div count\ d0)$

Appendix A4: Calculation of Consumption d 0-14

$$Feed\ in\ d0 - Feed\ out\ d9 + Feed\ in\ d9 - Feed\ out\ d13 + Feed\ in\ d\ 13 \\ - Feed\ out\ d14$$

Appendix A5: Calculation of FCR d 0-14

$$Consumption\ d0 - 14 \div (Pen\ weight\ d14 - initial\ weight\ d0 \\ + dead\ bodyweight\ d0 - 14)$$

Appendix A6: Calculation of Feed intake d 0-14

$Gain\ d14 \times FCR\ d14$

Week 4

Appendix B1: Calculation of Livability d 0- 28

$count\ d28 \div count\ d0 \times 100$

Appendix B2: Calculation of Body weight d 0- 28

$Pen\ weight\ d28 \div count\ d28$

Appendix B3: Calculation of Gain d 0- 28

$$(Pen\ weight\ d28 \div count\ d28) - (Initial\ weight\ d0 \div count\ d0)$$

Appendix B4: Calculation of Consumption d 14- 28

$$\begin{aligned} &Feed\ in\ d14 - Feed\ out\ d18 + Feed\ in\ d18 - Feed\ out\ d21 + Feed\ in\ d21 \\ &\quad - Feed\ out\ d24 + Feed\ in\ d24 - Feed\ out\ d26 + Feed\ in\ d26 \\ &\quad - Feed\ out\ d28 \end{aligned}$$

Appendix B5: Calculation of FCR d 0-28

$$\begin{aligned} &(Consumption\ d0 - 14 + Consumption\ d14 - 28) \div (Pen\ weight\ d28 \\ &\quad - initial\ weight\ d0 + dead\ bodyweight\ d0 - 14 \\ &\quad + dead\ bodyweight\ d14 - 28) \end{aligned}$$

Appendix B6: Calculation of Feed intake d 0-28

$$Gain\ d28 \times FCR\ d28$$

Week 6

Appendix C1: Calculation of Livability d 0-42

$$count\ d42 \div count\ d0 \times 100$$

Appendix C2: Calculation of Body weight d 0-42

$$Pen\ weight\ d42 \div Count\ d42$$

Appendix C3: Calculation of Gain d 0-42

$$(Pen\ weight\ d42 \div Count\ d42) - (Initial\ weight\ d0 \div Count\ d0)$$

Appendix C4: Calculation of Consumption d 28-42

$$Feed\ in\ d28 - Feed\ out\ 31 + Feed\ in\ d31 - Feed\ out\ d33 + Feed\ in\ d33 - Feed\ out\ d36 + Feed\ in\ d36 - Feed\ out\ d39 + Feed\ in\ d\ 39 - Feed\ out\ d42$$

Appendix C5: Calculation of FCR d 0-42

$$(Consumption\ d0 - 14 + Consumption\ d14 - 28 + Consumption\ d28 - 42 \div (Pen\ weight\ d42 - initial\ weight\ d0 + dead\ bodyweight\ d0 - 14 + dead\ bodyweight\ d14 - 28 + dead\ body\ weight\ d28 - 42)$$

Appendix C6: Calculation of Feed intake d 0-42

$$Gain\ d42 \times FCR\ d42$$

Week 8

Appendix D1: Calculation of Livability d 0- 56

$$count\ d56 \div count\ d0 \times 100$$

Appendix D2: Calculation of Body weight d 0- 56

$$Pen\ weight\ d56 \div Count\ d56$$

Appendix D3: Calculation of Gain d 0- 56

$$(Pen\ weight\ d56 \div Count\ d56) - (Initial\ weight\ d0 \div Count\ d0)$$

Appendix D4: Calculation of Consumption d 42- 56

$$Feed\ in\ d42 - Feed\ out\ d45 + Feed\ in\ d45 - Feed\ out\ d49 + Feed\ in\ d49 - Feed\ out\ d52 + Feed\ in\ d52 - Feed\ out\ d56$$

Appendix D5: Calculation of FCR d 0- 56

$$
\begin{aligned}
&(Consumption\ d0-14+Consumption\ d14-28+Consumption\ d28-42\\
&\qquad+Consumption\ d42-56\div(Pen\ weight\ d56-initial\ weight\ d0\\
&\qquad+dead\ bodyweight\ d0-14+dead\ bodyweight\ d14-28\\
&\qquad+dead\ body\ weight\ d28-42+sample\ bird\ weight\\
&\qquad+dead\ body\ weight\ d42-56
\end{aligned}
$$

Appendix D6: Calculation of Feed intake d 42- 56

$Gain\ d56\times FCR$ d56