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EFFECTS OF SOAKED FALSE YAM TUBER MEAL TREATED WITH BIOCHAR ON EGG LAYING PERFORMANCE AND BLOOD PROFILE OF CHICKEN

BY

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(Nutrition Option)

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DECLARATION

This is to affirm that this thesis has been authored by me and has neither been submitted for a degree nor any aspect published by another person elsewhere. Those whose work aided as source of material for my work have been duly recognized by reference in this work.

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ABSTRACT

A twenty-week feeding trial was carried out to determine the effect of 3% biochar (BC) in diets containing varying inclusion levels of soaked false yam tuber meal (SFYTM) on the performance of layer chickens. The false yam tubers were peeled and cut into pieces, soaked in tap water for 12 days, sun-dried and milled into gritty flour. The BC was obtained from milled wood charcoal. Three diets containing varying levels (4, 6 and 8%) of SFYTM with BC, a diet containing 4% SFYTM without BC and a control diet with no BC and SFYTM (Five diets in all).Two hundred and fifty (250) 49-weeks old (ISA Brown) hens of similar live weights were divided into five groups (10 hens/group) and each group replicated 5 times using CRD (Completely Randomise Design). Feed and water were given *ad-libitum* from. Parameters measured include mean feed intake, hen day egg production (HDP), egg weight, feed efficiency, feed cost and mortality. Apparent nutrient digestibility trial and blood profile analysis were conducted. Data were analyzed using 'GenStat 10th edition'. The apparent DM, CP and NFE of the control diet were higher ($P<0.05$) than those of the other 4 diets. However, CP digestibility of SFYTM at 4% with BC was higher ($P<0.05$) than SFYTM without BC. Mean feed intake of all the hens were similar ($P>0.05$). Hens fed SFYTM based diets with and without BC had similar ($P>0.05$) HDP; which were higher ($P<0.05$) than that of the control hens. However, other egg variables were similar ($P>0.05$). Blood profiles with exception of alkaline phosphatase were similar ($P>0.05$) for all hens. Mortality did not differ ($P>0.05$) among treatments. Feeding BC to layers reduce ($P>0.05$) feed cost by 8-14%.

Three (3) % BC used in layer diets containing up to 8% SFYTM had favourable effect on egg performance and the health of the animal.

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DEDICATION

I dedicate this work to my immediate family, especially my daddy: Mr. Siabi Elias Kwoa, for their passionate, inspirational, financial and physical supports throughout my life.

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ACRONYMS

ANF – Anti-Nutritional Factor

ANOVA – Analysis of Variance

BC- Biochar

BFYTM – Boiled False Yam Tuber Meal

CRD- Completely Randomized Design

FAO – Food and Agriculture Organization

FAOSTAT – Food and Agriculture Organization Statistics

HDP – Hen-day egg production

MOFA – Ministry of Food and Agriculture

NAES – Nyankpala Agricultural Experiment Station

NAS – National Academy of Science

NRC – National Research Council

NRI – National Research Institute

SARI – Savannah Agricultural Research Institute

SFYTM – Soaked False Yam Tuber Meal

CHAPTER ONE

1.0 INTRODUCTION

In many developing countries, poultry production is a major means of bridging the protein deficiency gap (Smith, 1990). According to Atuahene *et al*. (2010), poultry production is a key to fighting poverty, improving food security and providing livelihoods in developing countries including Ghana. However, the poultry industry is plagued with some challenges (Buamah, 1992). Some of the major challenges facing the industry include shortage or scarcity of feed, high cost of feed ingredients particularly maize and disease outbreak.

Maize is one of the principal cereal crops grown in the sub-Sahara of Africa. Maize is a primary source of energy and can contribute up to 9% protein, 60% energy and 98% starch in animal diets (Dado, 1999). Bell and Weaver (2002) reported that, about 85% of the world chicken dietary energy is derived from maize.

The major use of maize grain includes staple food for majority of Ghanaians, feed for farm animals such as poultry, and in the brewing of local drinks. The high demand of maize as staple food has put undue pressure on the poultry industry because the production of cereal grains in Africa, Asia, and pacific nations have never been adequate for human consumption and industrial use (Reddy and Qudratullah, 2004). This has resulted in increased price of maize leading to high feed cost in poultry production.

According to Aning (2006), the escalating prices and occasional shortage of maize have contributed immensely to the factors militating against increased commercial poultry production in Ghana. Thus, in addressing problems of high feed cost, there is a need to search for alternative feed resources for use in poultry production (Flake and Ashitey,

2008). To achieve maximize profit, many researchers have exploit the use of non-conventional feedstuffs such as cassava (Oluyemi and Roberts, 1979), mucuna beans (Mesuna, 2004), blood (Donkoh *et al.*, 1998) and agro-industrial by- products such as oilseed cakes (Nelson, 1998).

One plant resource of interest as a non-conventional energy feedstuff is false yam (*Icacina oliviformis).* It belongs to the family Icacinaceae, and is found mainly in the savanna regions of West and Central Africa (NRI, 1987). It is a drought and fire tolerant plant (Dei *et al.,* 2011a). It has a fleshy tuberous root which contains 80% carbohydrate (Fay, 1991) and its high starch content makes it potential substitute for maize in broiler chicken diet (Dei *et al*., 2011a).

Processing of false yam tuber such as soaking in water, and soaking with additives (E.g. Saltpeter and common salt) have been recommended to improve its nutritive value for broiler chickens and also reduce the cost of feeding (Dei *et al.*, 2011b). Mohammed and Dei (2014) reported that, feeding soaked false yam tuber meal (SFYTM) at 5% to laying chickens reduced egg production. This is because, the tuber contains anti-nutritional substances including gum-resins, which limit its utilization as food for human and animals (Fay, 1991).

Various processing methods do not completely remove ANF(anti-nutritional factors) limit the utilization of processed tuber and this have necessitated the need to process the tuber to reduce or eliminate the toxic components for effective utilization by poultry (Dei *et al.*, 2011b).

Charcoal, on the other hand refers to as wood biochar and is a light, black residue, consisting of carbon and any remaining ash. It is obtained by removing water and other volatile constituents from animal and vegetation substances with its utilitarian intention as the only difference it has from BC (Biochar), charcoal is produced for other reasons (E.g. heating, barbeque, etc.) than biochar (Verheijen *et al.,* 2009). Gerlach and Schmidt (2012) reported that BC (charcoal) can act as toxin binder in animal diets.

A preliminary study on the use of BC (wood biochar) in the diet of broilers containing false yam seed meal revealed that, wood BC has the potential of aiding utilization of false yam seed meal up to 140 g/kg in the broiler chicken diets (Mohammed *et al*., 2017). There is limited information on how soaked false yam tuber meal with biochar can influence the egg laying performance of layer chickens.

Therefore, this study was carried out to determine the effect of 3% biochar at varying levels of soaked false yam tuber meal in layer chicken diets on egg laying performance and blood profile of chickens.

1.1 OBJECTIVES

1. To determine the nutrient digestibility of diets containing 3% BC and SFYTM for layer chickens.
2. To determine egg laying performance of chickens fed diets containing 3%BC with varying levels of SFYTM.
3. To determine the influence of 3%BC with varying levels of SFYTM in the diets of laying chickens on their blood profile.
4. To assess economics of feeding SFYTM with BC to laying chickens.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1.0 The Demands of Foods of Animal Origin

The economic development of a country is normally accompanied by improvements in a country's food supply and the gradual elimination of dietary deficiencies (WHO, 2003). It has been estimated that the global population will increase from 6 billion people to 9 billion people between 2000 and 2050. According to Thornton (2010), the demand for animal food products in developing countries has been progressively growing. As Neumann *et al.* (2002) reported, animal-source foods supply is not only high-quality and readily digestible protein and energy but are also a compact and efficient source of readily available micronutrients. Several situations call for the increase in meat consumption. Among these are increases in human population, urbanization and income improvements being the main causes to increase the demands for food of animal origin (Steinfeld, 2004).

Speedy (2003) reported that the countries that consumed the least amount of meat per year are found in sub-Saharan Africa (SSA) and South Asia. However, as Jabbar *et al*. (2011) reported, rising global demands for animal products may be an opportunity for the animal producers. A recent survey of several countries found that 34% of the people surveyed in South Asia and 59% in SSA were suffering from severe energy deficiency (Smith and Wiseman, 2007). Both groups obtained 67% of their energy from staple foods (cereal grains, grain legumes, starchy roots and tubers) containing small quantities of only low-quality protein.

Their average per capita egg consumption was only 42 per year, compared with a global average of 153. Stunting and wasting in children less than five years of age, and slow mental development were seen mainly in rural areas of SSA.

Eight out of ten of those affected were among the poor. Diseases such as kwashiorkor and marasmus, both seen in underweight children, are associated with inadequate dietary energy and protein. Pregnant and lactating women as well as young children are particularly vulnerable. In SSA, only 8% of dietary energy comes from animal protein, compared with an average of 17% in all developing countries, and 28% in China (Farrell, 2013). To meet the demand for foods of animal origin, the greatest increase is expected from poultry and pigs, as well as eggs and milk (Speedy, 2003; Delgado and Narrod, 2002**)**.

2.2.0 POULTRY PRODUCTION

2.2.1 Definition and Types of Poultry

According to AH (2009), Poultry is a term used for any kind of domesticated bird, captive-raised for its utility, and traditionally the word has been used to refer to wildfowl (Galliformes) and waterfowl (Anseriformes) but not to cage birds such as song birds and parrots. Poultry can also be defined as domestic fowls, including chickens (*Gallus domesticus),* turkeys (*Meleagris gallapavo*), geese (*Anser anser*) and ducks (*Anas platyrhynchos*) raised for the production of meat or eggs and the word is also used for the flesh of these birds used as food (AH, 2009). Poultry is a term used to describe birds kept for profit (Oluyemi and Roberts, 1979).

2.2.2 The Poultry Industry

Poultry production has been documented to be the fastest developing segment in the animal's industry, and more especially in tropical and sub-tropical regions of the world (Daghir, 2009; Holik, 2009). This is as a result played by the poultry industry in serving as a critical source of animal protein in these regions. Poultry meat and eggs provide nutritionally beneficial food containing protein of high quality. This is accompanied by low levels of fat which have a favourable mix of fatty acids (FAO, 2013).

Poultry provide humans with companionship, food and fiber in the form of eggs, meat and feathers. In some parts of the world, many people love to raise and show chickens and other poultry species at fairs and other poultry shows (Darre, 2007). Others just love to raise them for backyard pets and for fresh eggs every day. There is a large commercial chicken industry that provides us with eggs and meat (Darre, 2007).

In rural communities, village poultry plays an essential role in homestead food production for household consumption and supplementary income. Nutritionally village poultry contributes to meeting the essential nutrient needs of families. Chicken and eggs provide a readily available, high-quality and inexpensive source of proteins, vitamins, and micronutrients accepted by all ethnic groups (Kattel, 2016).

Village poultry comprise of traditional sector which caters for the meat and egg needs of majority of a country's communities and a commercial segment established on imported hybrid layer and broiler strains that supply the needs of those in the urban centers (Koney, 1993). According to Koney (1993), higher demand for animal protein, notably poultry products in the past decades were as a result of increase in population, urbanization and standard of living in many developing countries including Ghana.

In order to satisfy this demand, large scale farms were established mainly in peri-urban areas and by 1970's to early 1980's an extensive poultry infrastructure had been established in Ghana.

The Ghanaian poultry industry ranges from backyard farms with hundreds of birds to commercial farms with thousands of birds (Aning, 2006). The commercial poultry production sector in Ghana can be categorized into large scale (above 10000 birds), medium scale (5,000 to 10,000 birds) and small scale (50 to 5,000 birds) enterprises (Aning, 2006). The domestic commercial farms are mainly owned by private individuals or a family.

About 20% of the total poultry sectors produce mainly eggs with some people having their own feed mills and others having hatcheries and parents' stock, forming the large-scale category (Flake and Ashitey, 2008). The medium and small scale also forms about 80% of the commercial poultry sector as they tend to rely on hatcheries for their day- old chicks and the feed mill operators for their feed (USDA, 2008). Farmers in developed countries make much profit as a result of abundance of conventional feed ingredients, vaccines, suitable environment, knowledge and skills which are not adequate in developing countries. Commercial feeding programmes are designed to improve feed-conversion with little feed cost which leads to increase in profit and affordable poultry products (Lilburn, 1988). The industry is divided into two, thus the layer (those raised purposely for egg production) and broiler (raised mainly for their meat) birds.

2.2.3 Opportunities of Poultry Production as a Preferred Animal-Source Food

According to Pant (2013) animal production is more likely to be increasingly affected by carbon constraints, environmental and animal welfare legislations. But, the poultry

production has a relative advantage over other animals due to its little global warming potential (Mengesha, 2011) whereas ruminants, are responsible for greenhouse gas emissions (Haagsman *et al*., 2009).

Moreover, ILRI (2006) reported that the genetic diversity of indigenous chicken is much higher than other livestock species which have a good adaptability for climate and disease.

For such reasons, the desire for poultry meat and eggs without taboos and the relative ease in establishing poultry as an industry is a driving force at the moment (Daghir, 2009). According to FAO (2009) reports, chicken is usually the cheapest of all domestic livestock meats, particularly for SSA (Sub-Saharan African) and South Asian countries. Poultry meat and eggs are highly nutritious, cheapest, without taboos and efficient in feed utilization (FAO, 2010).

2.2.4 World Egg Production and Consumption

Eggs are consumed in all nations, in all seasons, and by all categories of people, since it contains most nutrient required by the human body and are consequently the most wholesome and as a rule the cheapest, of animal food (Poultry Audit, 2008). FAO (2009) Poultry Meat and Egg Report portrays egg production of chickens as follows: Hens will begin laying frequently at approximately 18-20weeks of age which in commercial production systems final for approximately a year before being sent for slaughter. Producers start to photo-stimulate (control the light and its escalated) and alter the diet around 18 weeks of age in arrange to support egg production. When a flock enters egg production, the rate of egg lay will be around 10 to 20%, showing that 10 to 20% of the total flock is laying eggs at 18 to 22 weeks of age.

At almost 30 to 32 weeks of age, the flock rapidly comes to its crest of egg production (>90%) after which egg production decreases to around 50% of the hens.

According to the IEC (2009) as expressed in the FAO (2010) Poultry Meat and Egg Report, worldwide egg production has quickly developed over time. It has tripled since1970 when worldwide yield was almost 20 million tons compared with nearly 60 million tons in 2007. Specialists from IEC (2009) show that within a few years, the production of eggs will be greater than that of beef and veal (expecting the development rates stay decently steady).

It is evaluated that there are 4.93 billion egg-laying hens in the world (IEC, 2009) with around 800–1,000 million laying hens in China, 276 million hens in the united States, over 380 million hens in the EU-27, 133 million hens in India and 115 million hens in Mexico. Egg production in African countries has been increasing faster than the global rate, with Nigeria leading the league table of egg producers while Australia continues to lead the field in Oceania (GPT, 2015) Egg production in Africa expanded by 3.8% per year between 2000 and 2013. As this far exceeded the global growth rate of 2.3%, Africa's share of world output increased from 3.7% to 4.5%. In volume terms, production in Africa rose from 1.9 million tonnes to 3.1 million tonnes over this period.

In few countries, many of the hens are conventional breeds kept outside in villages and backyards or on small holdings. Over 60 % of the world's eggs are produced in industrialized systems, generally utilizing battery cages (IEC, 2009). In a few EU nations and in the United States, about all the hens are caged. The eggs from the hens are sold either in their shells to be utilize by restaurants and buyers or prepared into egg items that

are utilized afterwards in a wide extend of food items from soups and sauces to prepared dinners, cakes, rolls and sweets. In 2007, around 59 million tons (or 93.2 dozen eggs) were delivered around the world (IEC, 2009). Asia, the biggest egg production continent (58% of worldwide yield), delivered 34.4 million tons in 2007 and China, the world's biggest egg production nation, delivered 21.8 million tons (37% of worldwide egg generation). The EU produced just over 6.4 million tons, while the United States produces 5.3 million tonnes and Africa producing 2.8 million tonnes.

China is by far the world's largest consumer of eggs. Much of China's production is directly consumed fresh eggs (FAO, 2009) followed by the United States. Be that as it may, a major distinction in consumer preferences and egg utilization exists between the two countries. In the United States, around a third of production is processed eggs, and white eggs are more favored for table use than brown eggs. International Egg Commission (IEC) (2007) portrays egg consumption in the world as stated. Poultry meat and eggs are critical source of protein intake. Request for animal protein increases with income rise and the efficient conversion of feed into eggs fortifies animal protein intake.

Egg consumption per capital ranged widely among countries. In accordance with countries surveyed by the IEC (2007), consumption varied from as low as 47eggs/capital/year in India to a high value of 349 eggs/capital/year in China, as more eggs are eaten by one person each year than in any other country in the world. The country with the second highest per capital consumption of eggs is Mexico (345 eggs/capital/year), followed by Japan (323 eggs/capital/year). Egg consumption has been expanding continually in most Asian nations due to the developing purchasing power of a growing middle class of buyers.

Since Asia is home to generally 60% of the worldwide populace (GET, 2011), indeed a slight increment in per capital utilization in this region indicates, a development in worldwide egg consumption patterns. It can be seen from Table 1 that Asia has the highest egg production from the year 2000-2013. Concurring to GET (2011), Africa contributes one in six of the world's human populace, many of which live in the poorest nations in the world, hence not shocking to discover that the normal egg consumption/person at as it were 2.2 kg is well underneath the world. From the table below Africa is the second lowest egg producing continent from the year 2000-2013.

In spite of the fact that many questions can be required at the consumption data, the signs are that the amounts of eggs eaten per individual have appeared an upward drift from 2.0 kg back in 2000 to today's 2.2 kg level. This has been quite an accomplishment for African egg producers, having in mind that the human population expanded from around 820 million to 1,033 million between 2000 and 2010. By 2015, the population will have extended by a further 11% to around 1,150 million so egg industries in this region confront quite a challenge to indeed keep up normal consumption at the current level.

Table 1: World Egg production

Region	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
Africa	1.9	2.2	2.3	2.5	2.6	2.5	2.8	2.9	3.0	3.1
Americas	10.5	11.7	12.3	12.3	12.5	12.9	13.1	13.5	13.2	14.0
Asia	29.0	32.6	32.9	34.5	36.2	37.0	37.5	38.1	39.2	40.0
Europe	9.5	9.9	10.1	10.1	10.2	10.3	10.5	10.7	10.6	10.9
Oceania	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3
World	51.1	56.6	57.9	59.6	61.8	62.9	64.2	65.4	66.3	68.3

Source: **FAOSTAT (2013)** Totals may not add up due to rounding

Table 2: Egg Production in Ghana

Region	No. of farmers	Estimated no.of Egg (millions)
Greater Accra	421	542
Ashanti	697	5321
Brong Ahafo	510	3989
Central	312	437
Western	159	247
Eastern	213	358
Volta	98	68
TOTAL	2410	10964

Source: **FAO (2014)**

From Table 2, the summation of eggs in millions from the major egg producing regions in Ghana is 10964. But according to FAO, (2015) and SRID, (2014), the total numbers of eggs produced in 1000 metric tonnes are 33.7, 36.7, 36.7, 39.8 and 40.0 for the years 2008, 2009, 2010, 2011and 2012 in Africa respectively**.** For the period 2000-2011 poultry production has been markedly on the rise (FAOSTAT, 2013).

Ghana emerged as the 13th egg producing country in Africa, producing approximately about 36.7 thousand tonnes behind Nigeria, South Africa and Egypt and the 88th in the world in accordance to egg production ranking FAO (2011). Commercial egg production in Ghana is next in importance to village chicken keeping in the Ghanaian poultry industry (Okantah *et al.*, 2004). Egg sales face relatively minor competition on the market compared to poultry meat. The national egg production for 2005 is estimated, conservatively, to be 1570 million (FAO, 2005).

The Greater Accra, Ashanti, Brong Ahafo, Central and Western regions are the major egg producing regions in Ghana and have the most number of farms and produces about 66% of the country's total egg.

Table 3. Demand and supply of poultry meat and eggs in Ghana (1000 tonnes)

Year	Meat (Chicken, Turkey and Guinea fowl etc)				Eggs			
	Production	Export	Import	Supply	Production	Export	Import	Supply
2001	20963	0	12262	33225	22260	0	96	22356
2003	25543	823	56090	80812	24380	196	62	24246
2005	28763	64	52570	81269	25183	0	107	25290
2007	41730	29	80551	122252	31270	16	51	31305
2008	44460	0	76957	121417	33655	26	45	33674
2009	47970	18	80775	128727	36700	4	20	36716
2010	51675	0	112145	163820	36700	3	36	36733
2011	56550	-	-	-	39750	-	-	-

Source: **FAOSTAT (2013)**

Both meat and egg production have seen continues increase over the years in their demand. The high demand for these products necessitated the importation of both egg and meat as the country's production was never adequate. The government of Ghana exported less than 5% of the poultry meat produced and imported over 100% of the poultry meat consumed in the country. It can also be deduced however that, Ghana exported or imported less than 1% of its total eggs produced and consumed. The demand for meat was also higher than that of eggs.

2.2.5: Egg Consumption in Ghana

Many countries including Ghana have adopted intensive poultry production as a means of solving protein problems (Smith, 1990). Annual egg consumption has been increasing in Ghana from 1990 to 2002. Even though, egg consumption data for the recent past was not available as at the time of this write up, the average annual change in egg consumption

from 1990 to 2000 was 0.86 metric tonnes and from 2000 to 2002 was 0.55 metric tonnes, indicating a decrease in annual egg consumption between 2000 and 2002. Few countries actually directly measure egg consumption (IEC, 2007). Global Egg Trends (GET) (2011) indicated an increase in egg consumption in Ghana per person from 0.8 kg to 0.9 kg from the year 2000 to 2007.

2.2.6: Challenges of poultry egg production in Ghana

Out of the population of animals in Ghana in 1990 and 2010, poultry had the most elevated number but has a lower development rate (MOFA, 2010). This is due to the various challenges influencing the development of the industry. The poor hygienic conditions at the hatcheries (Appiah, 1993), the need of skilled personnel for center administration position (Daghir, 1995), the trouble in getting high quality day-old chicks (Oluyemi and Robert, 1988), the high temperature coupled with diseases in the tropics causes stress on the birds leading to more mortality (Raece and Lott, 1982) and high disease incidences such as Newcastle, Gumboro, Fowl pox, Chronic respiratory illness etc., which may be caused by poor biosecurity or sanitation (Appiah, 1993).

The shortage of feed ingredients and the high cost of feeding happen to be the major problems the industry in the tropical regions are facing (Sawant, 2008).

Feed ingredients such as maize (corn) which makes the bulk of feed and moreover the major source of dietary energy and protein supplements are vital for feed formulation. In numerous developing nations, the production of cereal grains and other feed is insufficient for human utilization needs. However, many poultry feeders depend on maize as the source of energy. These may lead to shortage and high cost of feed. In other Apart of the world, utilizing cereal grains particularly maize for feeding non-ruminants

including poultry maize has been redirected to the generation of biofuel creating high request with supply and subsequently, over the top costs (Chauynarong *et al*., 2009).

Feed cost alone accounts for 70 to 75% of the total cost of production in Ghana (Sawant, 2008). The layer industry is one of the agricultural sectors which is driving the economy but it has been faced with so many challenges among which include; high feed cost, acquisition of day old chicks, diseases, heat stress and lack of technical know-how. Other factors that influence the development of the poultry industry include technical knowledge, as science and technology evolves, availability of natural resources including water and solar energy as well as the management of trade barriers (Agyei-Henaku, 2016).

2.2.6.1: Poor quality day-old chicks

The local production of day-old chicks is one of the weaknesses in the poultry value chain. One of the reasons for low production of local day-old chicks is the absence of any legislative framework or policy to regulate the operations of local hatcheries. As a result, poor day-old chicks are produced. The number of hatcheries decreased from 28 in the 1980s to 10 in the 2000s (VSD, 2013). Additionally, most of the poultry hatcheries are only producing at about 60% of capacity due to low demand (GPRA, 2013).

Low demand for locally produced DOC (Day old chick) is due to high mortalities recorded during brooding and poor laying capacity of pullets.

2.2.6.2: Diseases

In the 1960s the major commercial poultry disease was Newcastle Disease (Calnik, 1997). From the 1970s to the present, Infectious Bursal disease (Gumboro Disease) has

become an additional threat to the poultry industry alongside Newcastle Disease (VSD, 2009). In rural poultry Newcastle disease had been and still remains the major disease of economic importance. This disease is characterized by the sudden onset of clinical signs, which include hoarse chirps (in chicks), watery discharge from nostrils, labored breathing (gasping), facial swelling, and paralysis, trembling and twisting of the neck (Calnik, 1997). Moderately pathogenic strains may show transient nervous signs and drastic reduction in egg-laying in addition to mild respiratory signs. Layer birds show sudden, severe drop in egg production, and the eggs laid are soft-shelled (Charlton, 2006). To protect village poultry against Newcastle disease, the Veterinary Service Department (VSD) introduced the thermostable Newcastle Disease I-2 vaccine. The Accra Veterinary Laboratory started mass production of the vaccine in 2002 after successful field trials in 2000 and 2001. The laboratory produced two million one hundred and thirty five thousand (2 135 000) doses of the vaccine in 2006 (VSD 2009).

Contagious Bursal Disease otherwise known as Gumboro is another popular viral disease, which usually affects birds between the ages of 3-7weeks. There is no treatment but birds are protected by vaccination on the 23rd day. Mortality is as high as 80% (Tachie-Menson, 1991).

Fowl pox also a viral disease affecting most species of poultry affects birds of all ages (except newly-hatched chicks) (Charlton, 2006).

2.2.6.3: Heat Stress

According to McDaniel *et al.* (1995), heat stress decreases productivity of chickens. Exposure of birds to more days of heat will lead to the core ambient temperature going above the thermo-neutral zone which adversely affects animals' survival (Bell and

Weaver, 2002). Heat stress is caused by long exposure to high temperatures. The normal body temperature of chicken is between 40-41.6 ^{o}C, and will fluctuate sometimes depending on the temperature of its environment (Mauldin, 1999). The use of flex-houses, wet feeding and provision of cool water or cool water mixed with recommended quantity of alcohol in times of high ambient temperature Mohammed and Dei, (2010) could help reduce the adverse effect of heat on poultry performance in the Savanna zone of Ghana.

2.2.7: Feeding and Feed Cost

Achievement of the outstanding performance of the poultry sector over the past three decades has partially been achieved through rising use of concentrate feed, particularly cereals and soybean meal (FAO, 2006). It was estimated that in 2004 the poultry sector across the world utilized a total of 294 million tonnes of feed, of which approximately 190 million tonnes were cereals, 103 million tonnes soybean meal and 1.6 million tonnes fishmeal (FAO, 2006).

Estimates put the global use of cereals for feed (all species included) at 666 million tonnes, or about 35% of total world cereal use (FAO, 2006). This implies that in 2004 cereal utilization as feed by the poultry sector (globally) represented about 28% of the cereal and 75% of soybean meal used by the livestock sector.

Demand for feed by the livestock sector has been a trigger for three major global trends: the intensification of feed production, agricultural expansion and erosion of biodiversity.

Due to the dominance of layer bird production, Ghana's poultry feed industry is mostly focused on layer feed. The main ingredients used for feeding are maize, fishmeal, premix,

concentrates and soybean. Except locally produced white maize, most feed inputs are imported. Prices of most inputs have increased over the last years. Controlling animal feed costs is critical as it amounts to 72 % of the variable production costs (USAID, 2013). Therefore, some feed manufacturers are switching to low-cost substitutes such as cotton-seed cake, palm kernel cake, soybean cake, copra cake, fish meal and other by-products of agro-processing. One of the major problems in the layer industry is feed which accounts for about 75 % of the entire cost in poultry farming and a critical factor in determining the profit gain (Kekeocha, 1984).

Maize obtained locally or imported yellow maize is the main energy ingredient in the diet of chicken. Maize forms about 50-60 % of the total feed formulation (Flake and Ashitey, 2008). Cost of feed prices in Ghana has been increasing, as a result of high cost of maize (Flake and Ashitey, 2008). In fact, the poultry industry consumes almost 30 % of all white maize produced in Ghana (FAO, 2014). According to Sonaiya (1993), the intensive and semi-intensive poultry production systems, which mushroomed in the 1970's almost collapsed due to grain deficit such as maize.

2.3.0: Ways to Solve Feed Problems

The feeding of chicken constitutes about 75% of the cost of producing eggs (Kekeocha, 1984). There have been several measures to reduce the cost of producing eggs. Among these are the use of non-conventional feedstuffs and the partial substitution of ingredients.

2.3.1: Substitution of ingredients

The increase in demand for conventional ingredients, invariably result in higher prices of feed inputs, thus feed inputs contribute 65-75 % of the total cost in intensive system of poultry production (Reddy and Qudratullah, 2004). The profitability of poultry industry in the developed countries is linked to cheap and abundance of conventional feed ingredients, which are lacking in developing countries. In most cases, some nutrients such as protein and energy components are often affected. The severities of feed scarcity and high prices have challenged animal nutritionists to exploit root and tubers (such as cassava) as a cheaper substitute for energy feedstuffs (Chauynarong *et al.*, 2009). According to Dei *et al*. (2014b) the substitution of maize with 2.5 % false yam tuber meal after treating it with 0.5% saltpeter solution had no adverse effect on egg production. Rice bran is recommended to be included in the layer diet not more than 15 % (Jacob, 2015). According to Chisoro (2016) however, a limit of 5 % cassava foliage can be included in layer diet due to the palatability problems associated to it. Also, addition of up to 6% silkworm to layer chicken diet increased egg production, growth as well as profitability. Amaranth, spent brewer's grains, spelt wheat, rice bran and rye serves majorly as substitute for energy whiles cotton seed meal, earthworms, camelina meal, sesame seed meal and potato protein also used to replace protein sources (Jacob, 2015)

2.3.2: The use of non-conventional feeds

The production of cereal grains in Africa, Asia and pacific countries have never been adequate for human consumption and industrial use (Reddy and Qudratullah, 2004). Many researchers over the previous years have been attempting to make great use

of the undiscovered vast feed resources that are readily accessible in the formulation of the diet for poultry and other animals.

To accomplish cost effective poultry production in the developing countries, some of the non-conventional feed resources that have been identified include cassava (Oluyemi and Roberts, 1979), mucuna beans (Mesuna, 2004), blood meal (Donkoh *et al.*, 1998) and agro-industrial by products such as oilseed cakes (Nelson, 1998).

According to Oppong-Anane K (2013), tropical crops such as cassava, plantain and yam meals are used as non-conventional energy feed source while palm kernel meal, cashew nut meal and Africa locust bean seed can be used as protein feed resources. Aziza *et al*. (2013) also fed some layers with camelina and flaxseed seed meal which also contains phytochemicals but the birds performed very well. *Camelina sativa* belongs to the Brassica family, and species of this family are high in various antinutritional factors such as non-starch polysaccharides, glucosinolates, and phenolic compounds such as phenolic acids and tannins (Aziza *et al.*, 2013). Aziza *et al*. (2013) also reported that camelina contains 27.5% fat whiles flaxseed contains 2.45% has been used to feed layer and that increased production.

Farmers worldwide use different types of unconventional feed resources as feed additives on the basis of their availability and economical consideration. A new plant resource of interest as a non-conventional feedstuff is false yam.

2.3.3: Inclusion Levels of Non-Conventional Feed

Non-conventional feed resources (NCFR) generally refer to all those feeds that have not been traditionally used for feeding livestock and are not commercially used in the

production of livestock feeds (Amata, 2014). Ingredients must be researched to determine optimum levels in feed (Wenger feed, 2017). Many by-products can be potentially used to reduce feed cost, but we must understand the influence of using the byproducts on animal performance. Often byproducts with proper nutrient values can be formulated into feed and result in no change in animal performance. Typically, there is a maximum inclusion level at which higher inclusion levels result in reduced animal performance and/or the ingredient is no longer cost effective to use (Wenger feed, 2017). These maximum inclusion levels can also vary by productive stage that is maximum inclusions might be lower in starter diets than finishing diets (Wenger feed, 2017).

Many non-conventional feeds have been fed to layers at different inclusion levels to examine their effect on bird's productivity and health. According to Anaeto and Adighibe (2011) when maize was replaced with graded levels of cassava root meal (CRM) as energy source in the diet of laying hens at inclusion levels of 25, 50, 75, and 100 %, dietary inclusion of CRM did not affect the health of the layers and there was no adverse effect on the measured production parameters. Feed cost was reduced and hence, more savings. Feeding camelina meal and flaxseed meal at 10 % and 10 % respectively resulted in higher egg production compared with a corn-soy-based control diet. Crude protein digestibility decreased significantly in camelina 10 % and flaxseed seed meal at10 % compared with control diets.

The varying of the inclusion level of false yam products in the nutrition of animals has been tried by many researchers. Inclusion levels of 50 g/kg, 75 g/kg and 100 g/kg of boiled false yam tuber (BFYTM) in the diet of layer chicken have been tried by Nani *et al*. (2014). It was reported from their work that an inclusion level of 50 g/kg had no

adverse effect on nutrient digestibility. According to Dei *et al*. (2014a), false yam tuber boiled in 1% sodium chloride solution can be fed up to 5% in layer diets without adverse effects on egg production.

False yam tuber was soaked in 1% salt solution an inclusion level 50 g/kg was economical but when the concentration of the salt solution was 5%, an inclusion levels of 2.5 and 5.0% had adverse effect on feed consumption and egg production (Dei *et al*., 2014). Soaked false yam tuber meal (SFYTM) can be added to the diet of layer chicken up to 40 g/kg (Dei *et al*., 2014a). According Mohammed *et al*. (2015), 50-100 g/kg of false yam tuber in the diets of pullet layers adversely affected protein digestibility of the diets and hen-day egg production and feed conversion ratio but had no adverse effect on their haematological profiles and egg qualities.

2.4.0: False yam Origin and Distribution

The false yam is indigenous to West and Central Africa and is found growing wild on light sandy soil in the savanna areas of Senegal, Gambia, Guinea, the northern part of Ghana and parts of Sudan (NAS, 2008). It thrives on a variety of soils and in several plant communities (Fay, 1991). The plant grows both in the forest (at least long edges) and savannah areas especially within Africa humid areas. This could be an outstanding life- support species for the Sahel and for the equally drought-fraught areas.

Table 4. Taxonomical classification of false yam

Kingdom	Plantae –plants
Subkingdom	Tracheobionta –vascular plants
Super division	Permatophyte –seed plants
Division	Magnoliophyta –flowering plant
Class	Magnoliopsida–dicotyledons
Subclass	Rosidae
Order	Celastrales
Family	Icacinaceae –icacina family
Genus	*Icacina*
Species	Senegalensis, 'Mumu', *Oliviformis*

Sources: **Fay (1987)**

According to NAS (2008), the false yam (*Icacina oliviformis*) is a shrubby perennial variable in form, which sends up glabrous or pubescent erect leafy shoots from a large underground fleshy tuber (figure 1a). The aerial stems are light green and may reach about 1m in height.

Fay (1987) reported that the false yam plant falls under the division Magnoliophyta (flowering plant). The flowers are conspicuous, usually white or cream and peduncle, ascending or erect, corymbose cymes, collected into a terminal leafless panicle, or the

lower peduncle arising from the axis of reduced leaves (NAS, 2008). The calyx is divided into five sections, the pointed lobes are bright green; the corolla is composed of five narrow, white or creamy-white petals, covered with silky hairs on their outside surface. The fruit (figure 1b) is a red ovoid berry approximately 2.5cm-3cm in length and 2- 2.5 cm in width.

It is covered with very short hairs and contains a thin layer of white pulp, approximately 0.26 cm thick, surrounding a simple spherical or ovoid seed. From Table 4 because the false yam plant produces seeds, it falls under the super division permatophyte (seed bearing plants)

Figure 1.False yam tuber attached to the plant (1a) and false yam fruits (1b)

Table 5. Various names of *Icacina oliviformis*

Location	Name
Gambia	Manankaso
Sudan	Pane
Senegal	Bankanas and Kouraben
Ghana (Northern Ashanti)	Abu ntope
Ghana (BunkpuruguYunyoo District)	Kwaliya
Ghana (East Manprusi and Bimobas)	Kpalbilia
Ghana (Dagomba's)	Tankoro
Congo	Mumu

Sources: NRI (1987), Woot-isuen and Jardian (1968)

2.4.1: Importance of false yam plant

From Table 5 the false yam plant is located in many places in Africa, has different names across the countries and between tribes in the same country. Many people rely on false yam products such as; fruits, seed and tuberous roots (NAS, 2008). The fruits, for instance, are widely enjoyed especially by children in some parts of Africa during the annual harvesting season. They are bright red, sweet and plum-like, and are usually consumed fresh. The seeds are also many and if dried, they turn rock hard, which then can be stored with negligible loss. It cannot be eaten raw due to the bitter substance known as 'gum resin' (Fay, 1991).

The tuber gives a rich source of starch in dry season (Fay, 1987). In order to decrease this substance, after collecting, the tubers are cut and soaked in clean water for a few days to mellow the tuber and filter out the bitter compounds. The tubers at that point are dried in the sun, milled, and sieved to remove fibre. The result is white, grayish or creamy-yellow flour. It is also softened into an eatable paste by cocking in boiling water. The flour too can be utilized for porridges and has approximately 10 % protein (NAS, 2008).

Table 6. Nutrient composition of false yam tuber and seed on dry matter basis (%)

Component	Tuber				*Seed*	
	Fay (1991)	NAS (2008)	Adeti (2010)	Dei *et al* (2011a)	Fay(1991)	NAS (2008)
Moisture	11.7	_	_	13.5	*12-13*	*13*
Crude Protein	10.3	4.4	6.46	5.4	*8*	*8*
Crude Fat	0.7	1.6	0.89	1.6	*0.1*	*0.1*
Total Carbohydrate	74.5	84.5	37.37	53.1 (starch)	*72-73*	*72*
Ash	2.8	_	2.76	2.8	*0.5*	_

Generally, the false yam tuber and seed have high carbohydrate content making it an energy source in the substitution of maize fishmeal-based diet in animal diets. Since, both products are low in crude protein content it needs to be fortified with high quality protein

source in poultry diets. The high carbohydrate content (Table 6) of both the seeds and tubers suggest that they are suitable for use as feed ingredients for monogastric (poultry, pigs etc.). The variations in nutrient composition of either the tubers or the seeds may be due to differences in processing methods and the geographical location of the plants.

Dei *et al*. (2011b) reported that, both the false yam seed and tuber meals (% as fed basis) contain some essential and non-essential amino acids (Table 7 and 8).

The CP content of the boiled false yam seed meal was higher (13.48) than what was found in the raw false yam seed meal (11.77) and also in the soaked (7.18) false yam seed meals (Table 8). The lysine content in the boiled false yam seed meal (0.42) was also observed to be higher than what was found in the raw seed meal (0.29) as well as the soaked (0.21) false yam seed meals (Table 8).

False yam seed meals generally have high crude protein and lysine contents than in the false yam tuber meals. Also CP is higher in the raw tuber meal (7.03) than in the boiled (4.54) and soaked (3.22) tuber meals (Table 7). The lysine content of the soaked tuber meals (0.21) were higher than in the raw (0.16) and boiled (0.19) tuber meals (Table 7).

Table 7. Composition of crude protein and amino acid concentrations of false yam tuber meals (% as fed basis)

Component	Tuber meal					
	Raw	Boiled	Soaked			
			9 days	12 days	15 days	Mean
Crude protein	7.03	4.54	3.42	3.23	3.00	3.22
Essential AA						
Methionine	0.01	0.03	0.02	0.02	0.01	0.02
Lysine	0.16	0.19	0.22	0.20	0.20	0.21
Threonine	0.06	0.08	0.07	0.06	0.06	0.06
Tryptophan	<0.04	0.04	<0.04	<0.04	<0.04	<0.04
Arginine	0.46	0.23	0.08	0.07	0.07	0.07
Isoleucine	0.07	0.09	0.09	0.07	0.07	0.08
Leucine	0.11	0.15	0.13	0.11	0.11	0.12
Valine	0.10	0.13	0.12	0.11	0.11	0.11
Histidine	0.10	0.11	0.13	0.12	0.13	0.13
Phenylalanine	0.06	0.08	0.07	0.06	0.06	0.06
Glycine	0.08	0.10	0.08	0.07	0.07	0.07
Non-essential AA						
Aspartic acid	1.72	0.58	0.16	0.19	0.13	0.16
Glutamic acid	0.33	0.29	0.24	0.17	0.16	0.19
Cysteine	0.02	0.02	0.01	0.02	0.01	0.01
Serine	0.13	0.14	0.16	0.14	0.14	0.15
Proline	0.10	0.12	0.12	0.11	0.11	0.11
Alanine	0.13	0.13	0.13	0.14	0.09	0.12
Tyrosine	0.08	0.09	0.08	0.08	0.08	0.08
Ornithine	0.01	0.02	0.01	0.02	0.00	0.01
Taurine	0.03	0.03	0.03	0.03	0.03	0.03

Source: **Dei *et al*. (2011a), AA-amino acids**

Table 8. Composition of crude protein and amino acid concentrations of false yam seed meals (% as fed basis)

Component	Seed meal					
	Raw	Boiled	Soaked			
			9 days	12 days	15 days	Mean
Crude protein	11.77	13.48	7.36	6.94	7.23	7.18
Essential AA						
Methionine	0.05	0.07	0.04	0.04	0.04	0.04
Lysine	0.29	0.42	0.22	0.19	0.23	0.21
Threonine	0.36	0.46	0.26	0.24	0.26	0.25
Tryptophan	0.08	0.12	0.09	0.01	0.01	0.01
Arginine	0.94	1.21	0.57	0.51	0.59	0.56
Isoleucine	0.62	0.86	0.47	0.43	0.48	0.46
Leucine	0.75	0.98	0.56	0.50	0.56	0.54
Valine	0.46	0.64	0.36	0.34	0.37	0.36
Histidine	0.21	0.31	0.17	0.16	0.17	0.17
Phenylalanine	0.44	0.59	0.35	0.31	0.35	0.34
Glycine	0.45	0.59	0.35	0.32	0.35	0.34
Non-essential AA						
Aspartic acid	1.18	1.45	0.76	0.69	0.74	0.73
Glutamic acid	1.78	2.14	1.05	0.92	1.02	1.00
Cysteine	0.03	0.04	0.02	0.02	0.01	0.02
Serine	0.43	0.52	0.31	0.27	0.30	0.29
Proline	0.40	0.49	0.28	0.25	0.27	0.27
Alanine	0.53	0.70	0.40	0.35	0.38	0.38
Tyrosine	0.28	0.44	0.19	0.18	0.19	0.19
Ornithine	0.01	0.02	0.01	0.01	0.01	0.01
Taurine	0.03	0.03	0.02	0.02	0.02	0.02

Source: **Dei *et al.* (2011b), AA-amino acids**

2.4.2: False Yam as Medicine

Some members of the Icacina genus have been reported to possess medicinal properties. The parts of Icacina plant which have been used for medicinal purposes include the leaves and tuber. In West Ashanti of Ghana, the tubers of false yam are reported to be used medicinally. The leaves are warmed and applied as dressing against pain, especially in the case of elephantiasis (Irvine, 1961).

Icacina trichantha is supposedly utilized as medication in provincial communities in Nigeria (Asuzu and Abubakar, 1996; Timothy and Idu, 2011). This is supported by the thought that it is considered as the most vitally, available each day in case of emergency; from now on, nearly all families have the soaked tuber in ethanol which is put away in stopped bottles.

False yam has ant-diabetic and antimicrobial activities (Asuzu and Abubakar, 1995). The tuber of *Icacina trichantha* is expressed to be utilized as medication in treating mumps (Ubom, 2008). Anti-oxidant properties have been reported to be present in certain species (Odukoya *et al*., 2006).

Leaves of certain species have been recognized to have anti-plasmodia action and are utilized in the treatment of malaria (Sarr *et al*., 2011). Some other species are recognized to show anesthetic properties in guinea pigs (Asuzu and Abubakar, 1996). Asuzu and Abubakar (1996) have reported anticonvulsant activities in *Icacina trichantha*. Tubers of *Icacina trichantha* have been used by herbalists to treat constipation and poisoning (Asuzu and Abubakar, 1996). Igbo people in Nigeria consider the species *Icacina trichantha* to be aphrodisiac, and it is applied on boils (Atawodi *et al*., 2014).

2.4.3: Limitation in the Use of False Yam

The false yam plant has many uses but have some issues regarding it accessibility and phytochemicals present in the plant.

2.4.3.1: Harvesting difficulties of false yam

Icacina species have expansive tubers extending between 35-100 cm in length, 30 cm in breadth and weighs 3-25 kg (Fay, 1987). Harvesting of the tuber is done physically using a pick axe supported with hoes. Due to the deep infiltration of the tubers, manual digging is difficult. The huge size of the tubers however, makes harvesting and carrying off the tubers difficulty. As a result of the challengers faced during harvesting process, the tuber named ‘abubntope’ in Northern Ashanti of Ghana literally implies ‘break hoes’. Diggers, shovels and plows can as well be broken as result of harvesting challenges (Fay, 1987).

2.4.3.2: Anti-Nutritional Factors

Certain feed commodities are neglected or underutilized due to undesirable nutrient availability or the bitterness of phytochemicals present.

A large number of anti-nutritional and/or possibly harmful compounds are found to be present in cereal grains, seeds of vegetables, and other feeds of plant origin utilized in the manufacture of poultry diets. Most of these substances are naturally occurring compounds. (E.g. Protein, alkaloids, glycosides and greasy acids). Such compounds can be generally inactivated by subjecting them to washing, soaking and heating forms.

Both the seeds and tubers of *Icacina* contain toxic compounds called (gum resins) and the compounds are identified as terpenes (Vanhaelen *et al*., 1986).

From Table 9, tannins are the highest phytochemical in the seed. False yam has also been reported to contain hydrocyanic acid, phytic acid and oxalic acid the same bitter compounds as cassava (Antai and Nkwelang, 1998). From table 9, saponin and flavaniods are also anti-nutritional factors present in the seed. These anti-nutritional factors hinder the animals' growth, reproduction and can even result in their death therefore, the need to process it to reduce these compounds so that the tuber can be used as feed for animals.

Table 9. Phytochemical Composition of Utu (*Icacina senegalensis*) Seeds

Sample (%)	(g/100g dry weight basis)
Oxalate	2.02 ± 0.015
Tannin	5.84 ± 0.012
Saponin	2.59 ± 0.012
Phytate	2.17 ± 0.012
Alkaloid	3.92 ± 0.025
HCN	3.39 ± 0.474
Flavonoid	2.82 ± 0.012

Source: **Okoronkwo *et al*. (2014)**

2.5.0: Classification of the Anti-Nutritional Factors

The anti-nutritional factors in plants may be classified on the basis of their chemical structure, the particular activities they affect or their biosynthetic pathways (Aletor, 1991). In spite of the fact that this classification does not include all the known groups of anti-nutritional components, it does show the list of those as often as possible found in human nourishments and animal feedstuffs. The anti-nutritional factors may be separated into two major categories.

They are: (1). Proteins (such as lectins and protease inhibitors) which are delicate to ordinary handling temperatures. (2). Other substances which are steady or safe to these temperatures and which incorporate, among numerous others, polyphenolic compounds (primarily condensed tannins), non-protein amino acids and galactomannan gums (Osagie,1998).

A single plant may contain two or more harmful compounds, for the most part drawn from the two categories, which include to the troubles of detoxification. According to Aletor (1993), they are classified as enzyme inhibitors (trypsin and chymotrypsin inhibitors, plasmin inhibitors and elastase inhibitors), Haemaglutinnins (concanavalin A and ricin), Plant enzymes (urease and lipoxygenase), Cyanogenic glycosides (phaseolunatin, dhurrin, linamarin and lutaustralin), Goitrogens (pro-goitrins and glucosinolates), Oestrogens (flavones and genistein), Saponins (soya sapogenin), Gossypol from *Gossypium species* example cotton, Tannins (condensed and hydrolysable tannins), (3) Amino acid analogues (BOAA, DAP, mimosine, and N-methyl-1-alanine), Alkaloids (solanine and chaconine), Anti-metals (phytates and oxalates), Anti-vitamins (anti-vitamins A, D, E and B_{12}) and finally Favism factors.

2.6.0: Biochemical Effects of the Anti-Nutritional Factors

The biochemical and toxicological/adverse impacts of plant's secondary metabolites (anti-nutritional factors) have been studied by a several authors (Fu *et al*., 2002). Anti-nutritional components decrease animal performance but can cause harmfulness amid periods of shortage when the feed rich in these substances is consumed by animals in huge amounts (Kumar, 1992). Cyanogenic glucoside on hydrolysis yields harmful hydrocyanic acid (HCN). The cyanide particle binds few protein structures; hinder development by affecting amino acids and utilization of related supplements.

They moreover cause intense harmfulness, neuropathy and death (Fernando, 1987). Alkaloids cause gastrointestinal and neurological disorders (Aletor, 1993). The glycoalkaloids, solanine and chaconine present in potato and Solanum spp. (Saito *et al*., 1990; Aletor, 1991) are haemolytically dynamic and poisonous to organisms and people. Tannins will result in decreased feed consumption in animals, bind dietary protein and digestive enzymes to form complexes that are not readily digestible (Aletor, 1993).

Galani *et al*. (2005) reported that high levels of anti-nutritional factors in feed affect CP utilization of some anti-nutritional factors in some feed can significantly reduce protein and amino acid digestibility up to 23% in rats, poultry, and pigs (Soetan and Oyewole, 2009). They also cause decreased palatability and reduced growth rate (Roeder, 1995). Saponins cause hypocholesterolaemia by binding cholesterol, making it unavailable for absorption (Soetan and Oyewole, 2009).

Saponins also cause haemolysis of red blood cells and are toxic to rats (Johnson *et al*., 1986). These anti-nutritional factors react with protein, enzymes, or essential amino acids and form various complexes, thus affecting digestibility and nutrient utilization in poultry (Pekel *et al*., 2012). Phytates bind minerals like calcium, iron, magnesium and zinc and make them unavailable (Nelson *et al*., 1968). Phytic acid also affects protein utilization by forming electrostatic linkages with lysine, arginine, and histidine, and there by inhibiting proteolytic enzymes (Oomah, 2001). Oxalates, like phytates, bind minerals like calcium and magnesium and interfere with their metabolism. They also cause muscular weakness and paralysis (Soetan and Oyewole, 2009). Oxalates also cause gastrointestinal tract irritation, blockage of the renal tubules by calcium oxalate crystals, development of urinary calculi and hypocalcaemia (Blood and Radostits, 1989). Jones *et al*. (1997) reported that oxalates cause nephrotic lesions in the kidney. Oxalate, phytate and tannins are anti-nutrients, which could be toxic when consumed in an unproce ssed food (Ojiako and Igwe, 2008).

The bioavailability of the essential nutrients in plant foods could be reduced by the presence in these plants of some anti-nutritional factors such as oxalates and cyanogenic glycosides (Akindahunsi and Salawu, 2005). Too much of soluble oxalate in the body prevents the absorption of soluble calcium ions as the oxalate binds the calcium ions to form insoluble calcium oxalate complexes. As a result of this, people with the tendency to form kidney stones are advised to avoid oxalate-rich foods (Adeniyi *et al*., 2009).

Alkaloids are also reported to cause alteration of normal foetal developments resulting in foetal malformation in ewes. These are caused by teratogenic alkaloids (Mulvihill, 1972). Glycoalkaloids are reported to cause haemolysis and toxicity to humans (Saito *et al*.,

1990; Aletor, 1991). Some plant alkaloids are reported to cause infertility (Olayemi, 2007). Saponins are characterised by a bitter taste and foaming properties. Erythrocytes lyses in saponin solution and so these compounds are toxic when injected intravenously. The anti-nutritional effects of saponins have been mainly studied using alfalfa saponins. In non-ruminants (chicks and pigs), retardation of growth rate, due primarily to reduction in feed intake, is probably the major concern (Cheeke and Shull, 1985). Such effects have also been noted when *Sesbania sesban* leaf meal (saponin 0.71%) was incorporated in a chick diet (Shqueir *et al.*, 1989). Furthermore, because saponins may also undergo bacterial degradation in the rumen, they may not retard the growth of ruminants. Nevertheless, recent studies indicate that they inhibit microbial fermentation and synthesis in the rumen (Lu and Jorgensen, 1987).

Ricin occurs in castor beans (*Ricinus communis*) which have been reported to cause poisoning in all classes of livestock. Due to ricin, de-oiled castor seed cake (CP 35%) is seldom used as a livestock feed. However, the mature leaves of *R. communis* have been found suitable for feeding to sheep (Behl *et al.*, 1986) hence precautions against bean contamination are necessary. Castor bean meal can be detoxified by autoclaving at 20 psi for 60 min for incorporation in sheep diets (Rao *et al.*, 1983).

According to Sulabo *et al*. (2013) and Son *et al*. (2013) the reduction of apparent digestibility of nutrients in monogastrics could be attributed to the presence of the high levels of NDF, ADF, insoluble fibers and NSPs (non-starch polysaccharides) because viscosity would increase in the small intestines and speed up the passage rate of ingesta (Dégen *et al*., 2007), and the apparent ileal digestibility of the nutrients would decrease.

High levels of dietary fiber lead to a reduction in the digestibility of energy, starch, protein and lipids in monogastric animals (Montagne *et al*., 2003; Walugembe *et al*., 2014).

2.7.0: Methods Used to Remove Anti-Nutritional Factors in Plant Products

Most of the toxic and anti-nutrient effects of anti-nutritional factors in plants could be removed by several processing methods such as soaking, boiling, autoclaving, fermentation and other processing methods (Soetan, 2008). Food processing methods such as boiling reduces the amount of these phytochemicals in plant products (Piorrock *et al*., 1984). According to Enechi and Odonwodu (2003), the toxic effects of oxalate, phytate and tannins could be avoided, provided the plant food is cooked before consumption.

Khokhar and Chauhan (1986) reported that in moth bean to remove the anti-nutritional factors, the dry seeds were given different treatments including soaking, sprouting and boiling and the changes in the level of the anti-nutritional factors were estimated. Soaking the seeds in plain water and mineral salt solution for 12 h decreased phytic acid to the maximum (46-50%) whereas sprouting for 60 h had the most pronounced saponin lowering effect (46%). The other methods of processing were less effective in reducing the levels of these anti-nutritional factors but that of heat treatment almost eliminated trypsin inhibitor activity while soaking and germination partly removed the activity.

El-Adawy (2002) reported different nutritional composition and anti-nutritional factors of chickpeas undergoing different cooking methods and germination. Soaking could be one of the processes used to remove soluble anti-nutritional factors, which can be eliminated

with the soaking solution (Akande and 2010). However, some metabolic reactions can take place during soaking which will affect some of the constituent compounds (Vidal-valverde *et al*., 1992). Dhurandhar and Chang (1990) soaked navy and red kidney beans for 18 hours in water at ambient temperature and both showed insignificant decreases in typsin inhibitor activity. Nath *et al.* (1983) stated that the principal growth retarding factors of neem seed cake were believed to be water soluble. Odunsi *et al*. (2009) citing Nath *et al.* (1983), reported that soaking of neem seeds in water improves the crude protein content and palatability of the cake. The higher crude protein content obtained in water-treated neem seeds than the untreated neem seeds after soaking seeds in water for 72 h gave (Odunsi *et al.*, 2009). There was no any loss of activity when black beans were soaked in water for 16 h (Trugo *et al*., 1990).

Autoclaving entails cooking under pressure and the time of cooking is shortened by this method (Akande and Fabiyi, 2010). When jack beans were autoclaved for 30 minutes at 125 ^{o}C and 151b pressure, thermo-labile inhibitory substances such as cyanogenic glycosides, saponins, terpenoids and alkaloids could not be detected after autoclaving (Udedibie and carlini, 1988).

Kessler *et al*. (1990) stated that there was little nutritional advantage in autoclaving for more than half an hour. They reported that autoclaving of Jack beans was a satisfactory technique for ensuring survival of birds receiving jack beans diets.

Autoclaving for 10 minutes ameliorated the anti-nutritional factors but did not improve upon its feeding quality. However, combined heat treatment and water washing rendered the neem kernel as good protein supplement compared to groundnut cake (Uko and Kamalu, 2008). Even though the processed neem kernel supported final weight of

broilers similar to groundnut cake, growth rate of the experimental birds fluctuated throughout the period of feeding (Uko and Kamalu, 2008).

2.8.0: Processing of False Yam and utilization

For non-conventional food resources, processing is often carried out to either reduce or eliminate anti-nutritional factors which inhibit its intake, quality and suitability for better utilization (Adeti, 2010). It is therefore necessary to find ways of processing to reduce these anti- nutritional factors if not eliminated completely for better usage. False yams have undergone processing such as soaking, drying, boiling and fermentation, etc.

2.8.1: Soaking

Soaking is the process of immersing a substance completely in a liquid and leaving it to stand for a required period (NAS, 2008). After acquiring the false yam tubers, they are sliced and soaked in clean water for several days to soften the tuber and leach out the bitter compounds. There is a significant reduction in gum resin contained in false yam if the water during soaking period is repeatedly changed (Dei *et al*., 2011a).

According to Dei *et al.* (2010), soaked false yam tuber meal can replace maize up to 9 % in broiler chicken diet. Also maize up to 10 % in Ashanti Black weaner pigs' diet had no negative effects on their growth performance when the false yam tuber was soaked in water up to 12 days (Dei *et al.*, 2013).

As reported by Dei *et al*. (2012), the seed of false yam should preferably be soaked for a duration of 12 days before used for feeding broiler diets after evaluating the effect of soaking duration (9, 12 and 15-days respectively) on the nutritive value of the seeds for broiler chickens.

Table 10. Effect of false yam tuber soaked in 0.1% saltpeter solution on feed intake, weight gain and gain to feed ratio of broiler chickens (3-8 weeks of age)

Parameters	0% SPSFYTM	8% SPSFYTM	10% SPSFYTM	12% SPSFYTM	±SED	P-value
Feed intake (g/b/d)	119.4	120.9	117.6	115.5	3.37	0.461
Weight gain (g/b/d)	40.58	37.40	37.15	37.15	1.306	0.078
Gain to feed ratio	0.34	0.31	0.32	0.31	0.016	0.307

Source: **Asare (2013)** SED=Standard Error of Difference, P=Probability

Table 11. Effect of false yam tuber soaked in sodium chloride solution on feed intake, weight gain and gain to feed ratio of broiler chickens (3-8 weeks of age).

Parameters	Control	8%	10%	12%	±SED	P-value
Feed intake (g/b/d)	98.7	95.1	97.5	100.6	3.59	0.519
Weight gain (g/b/d)	42.2^{a}	33.4^{b}	35.0^{b}	33.0^{b}	2.759	0.030
Gain to feed ratio	0.43^{a}	0.35^{b}	0.36^{b}	0.33^{b}	0.021	0.005

Source: **Owusu (2013)** SED=Standard Error of Difference, P=probability, means with the same letter are not significantly different (p >0.05).

Inferences from the Table 11 also indicate that false yam tuber soaked in sodium chloride solution when fed at 8-12% improved feed intake but had adverse effects on growth performance and carcass characteristics of broiler chicken.

2.8.2: Drying

Drying can be carried out either using the solar radiation (sun drying) or mechanical driers (electric or fuel) depending on one's economic viability. A proper sun drying can be achieved between 1-3 days in the dry season and up to 8 days in the rainy season (Fay, 1991). Sun drying results in a greater loss of water. According to Dei *et al.* (2011), sun dried false yam tuber reduces the anti-nutritional factors and can replace maize at 3% in broiler chicken diet.

2.8.3: Fermentation

Fermentation is the energy-yielding anaerobic metabolic breakdown of nutrient molecules, such as glucose without net oxidation (Saunders, 2007). According to Antai and Nkwelang (1998), the fermentation of *Icacina manii* paste for six days resulted in a marked decrease in the level of toxicants. The reduction ranging from 178 mg/kg to 70 mg/kg for hydrocyanic acid, 638 mg/kg to 463 mg/kg for oxalic acid and 49 mg/kg to 21 mg/kg for phytic acid). According to Teog (2010), the fermentation of false yam tuber meal did not improve its nutritional quality for broiler chicken.

2.8.4: Boiling

Boiling is cooking in water above 100 °C in such a way that the water turns to vapour upon reaching a boiling point, often with the formation of copious bubbles of vapour in the liquid. Boiling is essential because it reduces some of the anti-nutrients in feedstuffs. Dei *et al.* (2011a) reported that boiled false yam tuber meal reduced anti-nutritional factors (gum resin) by 39.2% and can be substituted for maize up to 9% in the diet of broiler chickens with favorable effect on growth performance. According to Dei *et al.*

(2014) feeding boiled false yam tuber meal at lower dietary levels (≤4%) had favourable effects on egg production.

Table 12. Effect of boiled false yam tuber meal (BFYTM) on growth performance and carcass yield of broiler chicken (3 – 8 weeks of age).

Variable	Dietary BFYTM (%)					
	0	3	6	9	Pooled SEM	*P*-value
Feed intake (g/bird per day)	114.8	116.5	119.8	117.3	3.41	NS
BW gain (g/bird per day)	50.8	52.4	52.9	51.5	3.70	NS
Bird BW at 56 d (kg/bird)	2.16	2.21	2.23	2.18	0.129	NS
G:F (g/g)	11.44	0.45	0.44	0.44	0.020	NS
Mortality (%)	2.00	1.67	0.33	1.00	0.62	NS
Dressed carcass (% of BW)	73.6	74.8	74.0	72.9	1.19	NS

Source: **Dei *et al*. (2011a)** Values are means of 10 birds from 3 pens (n = 30).2Values are means of 2 males and 2 females from 3 pens/diet (n = 12; 6/sex) Not significant (P >0.05).

The growth performance of the broiler chickens when BFYTM is substitute for maize in the diets indicates that its feeding up to 9% in the diet had no adverse effect on their growth performance.

2.9.0: Effect of Processing on Plant Product Nutrient

Cooking treatments and or germination causes a decrease in fat, total ash, carbohydrate fractions, anti-nutritional factors, minerals and B-vitamins (El-Adawy, 2002). Germination was less effective than cooking treatments in reducing trypsin inhibitor, hemagglutinin activity, tannins and saponins; it was more effective in reducing phytic acid, stachyose and raffinose. Cooking treatments and germination decreased the

concentrations of lysine, tryptophan, total aromatic and sulfur-containing amino acids (El-Adawy, 2002).

However, cooked and germinated chickpeas were still higher in lysine, isoleucine and total aromatic amino acid contents than the FAO/WHO reference. The losses in B-vitamins and minerals in chickpeas cooked by microwaving were smaller than in those cooked by boiling and autoclaving. Germination resulted in greater retention of all minerals and B-vitamins compared to cooking treatments. *In vitro* protein digestibility, protein efficiency ratio and essential amino acid index were improved by all treatments. The chemical score and limiting amino acid of chickpeas subjected to the various treatments varied considerably, depending on the type of treatment.

Mosha *et al*. (1995) reported the effect of blanching on the content of anti-nutritional factors in selected vegetables. Levels of both tannic acid and phytic acid were significantly reduced by conventional and microwave blanching methods while oxalic acid levels were not significantly reduced in most of the treatments by either of the blanching methods. In general, they recommended blanching as an effective method for reducing the anti-nutritional factors in green vegetables; however, further investigation on the heating times for both conventional and microwave blanching methods has been suggested (Soetan and Oyewole, 2009). Alonso *et al*. (2000) reported the effects of extrusion and traditional processing methods on anti-nutrients and *in vitro* digestibility of protein and starch in faba and kidney beans.

De-hulling significantly increased protein content and greatly reduced condensed tannin and polyphenol levels in both legumes (Soetan and Oyewole, 2009). Extrusion was the best method to abolish trypsin, chymotrypsin, amylase inhibitors and haemagglutinating

activity without modifying protein content. Furthermore, this thermal treatment was most effective in improving protein and starch digestibility when compared with dehulling, soaking and germination. Van Bruggen *et al*. (1993) reported the methods and devices for reducing the amount of anti-nutritional factors in a mixture of raw material for animal feed.

Due to the steam treatment, the ant-nutritional factors are at least partially broken down and determined constituents such as fats also become better accessible, whereby the nutritional value of the final animal feed increases. Plant phytochemicals exhibit diverse pharmacological and biochemical actions when ingested by animals and man (Soetan, 2008).

2.10.1: Poultry

The poultry industry has been divided into two categories, which are the broiler industry and layer industry. Several research works on false yam tuber products have been conducted using broiler and layer chickens.

2.10.2: Broiler Chickens

In determining the effect of false yam tuber on performance of broiler chickens, several research works had been conducted which includes treatment of false yam tuber with saltpeter. Table 10, shows a study conducted to determine the effect of false yam tuber soaked in saltpeter solution on the performance of broiler chicken. The result indicated that false yam tuber soaked with saltpeter solution had no adverse effects on broiler growth performance and carcass characteristics when fed up to 12% in their diets.

2.10.3: Layer Chickens

Table 13 shows the effects of processed false yam tuber meal on the growth performance of layer chickens. The author indicated that, there was no adverse effect on their laying performance when boiled false yam tuber was added to diets of growing pullets at 25 g/kg whiles table 13 indicated that, there was an adverse effect on egg production when boiled false yam tuber meal was added to the diet of layers.

Table 13. Effect of BFYTM on the performance of layer chickens (19-35 weeks of age)

Parameters	Dietary BFYTM levels(g/kg)					
	0	50	75	100	SED	p-value
Feed intake (g/hen/day)	90.1	93.1	92.7	92.8	1.57	0.078
HDP (%)	60.3^{a}	51.2^{b}	47.7^{b}	43.1^{c}	3.54	0.003
Egg weight(g)	48.6	47.8	48.3	47.8	0.45	0.013
Egg mass(g/hen)	21.5^{a}	24.4^{b}	23.6^{b}	21.2^{c}	1.95	0.008
Feed-egg mass ratio	3.04^{a}	3.85^{b}	3.95^{b}	4.48^{c}	0.34	0.008
Mortality	0/60	1/60	3/60	2/60	-	-

Source**: Nani (2014)** SED=Standard Error of Difference, p=Probability

The effect on performance of layers (Table14) showed that feed consumption of hens in all treatments was similar but egg production trend reduced as the SFYTM increased in the experimental diets. Mohammed and Dei (2013) indicated that, addition of SFYTM to the diets affected protein and fat digestibility of hens. Since, residual concentrations of ANFs might have affected major nutrients (protein and fat) which are components of egg. Hence, egg laying performance was reduced.

Table 14. Effect of SFYTM on performance of layers (19-35 weeks of age)

	Dietary SFYTM levels (g/kg)					
Parameter	(0)	50	75	100	±SED	P-value
Feed intake (g/bird/day)	89.6	94.2	93.3	92.1	2.33	0.203
Hen-day egg production (%)	60.3^{a}	51.2^{b}	44.1^{c}	39.9^{c}	3.23	<0.001
Mean egg weight (g)	48.5	48.3	49.3	47.9	0.68	0.246
Mean egg mass (g)	29.5^{a}	24.4^{b}	21.5^{b}	18.9^{b}	1.47	<0.001
Feed/egg mass	3.04^{a}	3.88^{b}	4.34^{b}	4.96^{c}	0.298	<0.001
Mortality (%)	0.00	0.50	0.75	1.00	0.489	0.259

Source: **Mohammed and Dei (2013)** SED-standard error difference, P- probability, means with the same superscripts in a row are not significantly different (P>0.05)

2.10.3.1: Effect of varying levels of false yam tuber meal on egg characteristics.

Egg quality is composed of those characteristics of an egg that affect its acceptability to consumers, it is therefore important that attention is paid to the problems of preservation and marketing of eggs to maintain the quality (Adeogun and Amole, 2004). Considering internal egg quality characteristics, thick albumin is quite an important measure for the freshness of an egg (Toussant and Latshaw, 1999). Among many quality characteristics, external factors including cleanliness, freshness, egg weight and shell weight are important in consumer's acceptability of shell eggs.

On the other hand, internal characteristics such as yolk index, Haugh unit, and chemical composition are also important in the egg product industry as the demand for liquid egg, frozen egg, egg powder and yolk oil increases (Silversides and Scott, 2001). According to Mohammed *et al*. (2015), albumen height, Haugh weight, Albumin weight, Yolk weight, shell weight and shell thickness did not differ between birds fed diets containing SFYTM at 5,7.5 and 10% but, birds fed diets containing SFYTM tended to have better albumen height, and egg protein quality values than those birds fed control diet.

Egg weight (g) and egg mass (g/hen) did not differ when false yam tuber meal was boiled in 1% sodium chloride at inclusion levels of 2.5 and 5% (Dei *et al*., 2014b). When the concentration of the sodium chloride was increased to 5% egg mass and egg weight was still the same (Dei *et al*., 2014c). According to Dei *et al*. (2014d), when SFYTM was incorporated in the diet at lower levels of 2 and 4% egg mass and egg weight were insignificant.

2.10.4: Pigs

False yam has also been tested as a potential non-conventional feed ingredient in pigs, other monogastric animals in which high conventional feed cost is a major limitation to the industry. Table 15 and 16 shows evaluation of soaked and boiled false yam tuber meal in the diet of Ashanti Black weaned pigs.

Table 15. Effects of varying levels of soaked false yam tuber meal on performance of Ashanti Black Pigs (12-20 Weeks of age).

Parameters	T0	T5	T10	T15	SED	P-VALUE
Initial Live Weight (kg/pigs)	6.19	5.31	5.43	4.63	0.633	0.186
Feed Intake (g/pig/day)	803	689	721	601	64.4	0.075
Final Live Weight at Week 20 (kg/pig)	23.2[a]	20.85[a]	20.86[a]	17.6[b]	1.51	0.032
Live weight Gain (g/pig/day)	306[a]	261[a]	263[a]	213[b]	23.4	0.027
Gain/Feed Ratio	2.62	2.48	2.62	2.60	0.077	0.256

Source: **Amewonye (2013)** SED: Standard Error of Difference. P- Probability. Means with different superscripts differed significantly ($P < 0.05$).

Considering the various growth parameters measured (table 15), Soaked False Yam Tuber Meal (SFYTM) can replace maize up to 10% in Ashanti Black Weaner pigs' diet without any adverse effects on their growth performance.

Table 16. Effects of varying levels of Boiled false yam tuber meal on performance of Ashanti Black Pigs (12-20 weeks of age)

Parameters	T0	T5	T10	T15	SED	P-VALUE
Initial live weight(kg/pig)	6.19	5.34	5.10	5.09	0.580	0.261
Feed intake (g/pig/day	803.0[a]	680.0[a]	553.0[b]	440.0[b]	84.1	0.013
Final weight (kg/pig)	23.33[a]	21.32[a]	16.36[b]	9.86[c]	1.317	<0.001
Live weight gain (g/pig/day)	307[a]	284[a]	203[b]	83[c]	23.1	<0.001
Gain/feed ratio	2.62[b]	2.38[b]	2.76[b]	5.16[a]	0.641	0.008
Mortality	0/6	0/6	0/6	1/6	-	-

Source: **Getsey (2013)** SED=standard error of difference. P-probability means with different superscripts differed significantly (P<0.05).

From the findings of the above table, feeding 5%BFYTM in the diet of the Ashanti Black weaned pigs as a substitute for maize had no adverse effect on their growth performance.

2.11.0: Biochar

Biochar is a carbon rich product produced from the incomplete combustion of biomass in the absence of oxygen through a process termed pyrolysis (Kutlu *et al*., 2001). Biochar is pyrogenic black carbon derived from the pyrolysis of biomass, such as wood and grass,

under nitrogen or oxygen limited conditions (Lehmann *et al*., 2006; Rutigliano *et al*., 2014).

Biochar has gained research interest because it has the potential for use in mitigating global warming effects (Beesley *et al*., 20011; Cabrera *et al*., 2011). In addition, biochar has applications in soil fertility improvement, plant growth, and decontamination of pollutants such as pesticides, heavy metals, and hydrocarbons. The diverse range of biochar applications depends on its physicochemical properties, which are governed by the pyrolysis conditions (heating temperature and duration) and the original feedstock (Enders *et al*., 2012). Thus, detailed information about the complete production process is a key factor in defining the most suitable application of biochar.

The biochar physicochemical properties can cause changes in the soil nutrient and C availability, and provide physical protection to microorganisms against predators and desiccation; this may alter the microbial diversity and taxonomy of the soil (Lehman *et al*., 2011).

Biochar prepared from relatively low-temperature pyrolysis is characterized by a high content of volatile matter that contains easily decomposable substrates, which can support plant growth (Mukherjee and Lal, 2013). In contrast, the structure of biochar derived from high temperature pyrolysis is characterized by a large surface area and aromatic-carbon content, which may increase the adsorption capacity (a desirable property for bioremediation) as well as the recalcitrant character (for carbon sequestration) (Lehmann, 2007). Activated carbon can be produced from a number of agricultural materials such as hardwoods, grain hulls, corncobs, and nutshells (Young, 1996). Steam activation can also be used with food-grade carbonaceous material (Burdock, 1997).

Acid treatment is also common. For example, pecan shells can be activated by treatment with hydrochloric acid, and then heated in an electric furnace for four hours at 800-1,000°C in an atmosphere of carbon dioxide (Young, 1996). Among the other 47 raw materials used as raw materials to make activated carbon are sawdust, peat, lignite, coal, cellulose residues (Lambiotte, 1942), and petroleum coke, spent ion exchange resins such as styrene-divinyl benzene polymers (von Blucher and De Ruiter, 1999).

Under European Union regulations, biochar is carefully defined and approved for use in agriculture, but currently, most is fed to livestock, and then spread on land with manure (Yarrow, 2015). Animal's water and feed can be exposed to contaminants from rodents, flies or birds; for example, many poultry farmers are following an age-old practice of adding charcoal to drinking water or feed (Yarrow, 2015)

2.11.1: Processing of Biochar

Biochar is created through pyrolysis, a decomposition of organic material in a non- or reduced-oxygenated, enclosed environment with heat. This process usually occurs in one of two forms of which one occurs fast (taking no more than a few seconds) and the other which is slower (which can take hours). According to Mukherjee and Lal (2013) all biochar do not have the same properties but depends on the material used in the processing of the biochar. Pyrolysis typically takes place at temperatures between 350 and 500 degrees °C (Laird, *et al*., 2009; Wolfe, *et al*., 2010) and its product yields, by mass, are typically 50 to 70% bio-oil, 10 percent to 30% biochar, and 15 to 20% biogas (Laird *et al*., 2009). Variation in end-product percentages is dependent on the temperature and type of pyrolysis as well as the organic input.

Estimates place the amount of biochar produced using low temperature pyrolysis to be at about a 50% conversion of biomass carbon, with another 33 percent converted to biofuel (either bio-oil or syngas) (Lee *et al*., 2010). Ideally, it will be possible to capture all three pyrolysis byproducts helping to make the system profitable (Demirbas, 2004; Lee *et al*., 2010). Biochar itself is a carbon-rich, highly porous material containing polycyclic aromatic hydrocarbons (Atkinson *et al*., 2010) and having a molecular structure that is highly chemically and microbially stable (Cheng *et al*., 2008). Many types of biomass are suitable for biochar production and several studies have considered a wide range of materials (Demirbas, 2004; Balat and Balat, 2009).

2.11.2: Biochar as Feed Supplement

Several research projects have been done over the past years to better understand the benefits of biochar as a feed supplement for broilers. Gerlach and Schmidt (2012) found biochar deactivated toxins already in the digestive system, positively activating intestinal flora and vitality. Teleb *et al.* (2004) observed that a diet supplement of 0.5% biochar made from locally available wood overcame the detrimental effects of feeding broilers 30 ppb aflatoxin by showing reduced mortality rates and improved growth rates when compared to those fed 30 ppb aflatoxin without biochar.

Kutlu *et al.* (2000), Kana *et al.* (2010), Jiya *et al.* (2013) and Prasai (2013) reported a significant increasing growth rates and higher final body weights for broilers fed diets supplemented with 0.2% - 0.6% biochar made from oak, maize cob, seed of Canarium, coconut shell and locally available wood. However, these and other studies also found that too much biochar in the diet can be deleterious. Odunsi *et al.* (2007), Kana *et al.*

(2010) and Jiya *et al.* (2013) all found depressed growth rates and final body weights for broilers fed diets supplemented with 2% or more biochar.

Doydora *et al.* (2011), Ritz (2011) and Prasai (2013) observed that when used as a feed additive for broilers, biochar made from pine chips, peanut hulls and locally available wood significantly reduced the amount of ammonia and phosphorus in droppings, therefore requiring smaller land area on which to spread the litter.

Table 17. Average Broiler Weight Gain by Treatment

Treatment	Average Placement (g/bird) [a]	Average 7 Day (g/bird)	Average 14 Day (g/bird)	Average 21Day (g/bird)	Average 28 Day (g/bird)	Average 35Day . (g/bird)[b]
T1 (0% biochar)	42.75	197.00	472.66	1,025.66	1,751.6	2,608.89
T2 (0.5% biochar)	42.15	194.84	477.8	1,020.19	1,714.99	2,561.16
T3 (1% biochar)	42.97	199.28	467.81	996.80	1,696.83	2,536.59

Source: **Dickson (2015)** a-values are not significantly different (P=0.574), b- values are not significantly different (P=0.387)

Table 18. Average Feed Consumption, Feed Conversion Ratio and Mortalities by Treatment

Treatment	Average Feed Consumption (grams)[a]	Average Feed Conversion Ratio [b]	Mortalities #	Mortality %
T1 (0% biochar)	48,415	1.56	1	1.04%
T2 (0.5%biochar)	47,004	1.58	3	3.13%
T3 (1% biochar)	47,499	1.63	4	4.17%

Source: **Dickson (2015)**

From table 17 and 18 supplementing broiler feed with broiler litter biochar had no statistically significant impact on broiler weight gain, feed consumption, feed conversion ratio or health. According to the researcher reason as to why supplementing broiler feed with biochar had no significant impact could be because broiler litter was used and also studies that found significant increases in growth rates from supplementing broiler feed with biochar, different feed stocks were used to make the biochar; including oak, pine, coconut shells, corn cobs, peanut hulls and seed of Canarium.

2.11.3: The Use of biochar in litter

According to Yarrow (2015) an immediate, obvious use of biochar is to reduce even eliminate gases and odors from manure and urine, especially ammonia. Biochar has a strong affinity for gases, liquids and ion and ammonia (NH_4^+). Activated carbon's effectiveness for odor control is well known, and preferred in air purifiers. So, a farmer's first small step is to blend 5 to 20% biochar with conventional litter to spread on a barn or coop floor. Ammonia's strong positive electric charge makes it corrosive, toxic to breathe, electron thief, thus a serious health stress. This gagging gas emitted by bird droppings, animal poop and pee, makes air unhealthy, toxic to birds and humans. Ammonia irritates skin on contact, and degrades even hard tissue, such as hooves and it also attracts insects, such as flies (Yarrow, 2015).

Biochar has a very high water holding capacity and can absorb up to 5 times its own weight of water (Gerlach and Schmidt, 2012). Biochar adsorbs very efficiently both organic molecules such as amino acids, fatty acids, proteins and urea and also mineral compounds such as ammonium, ammonia and nitrate. Used in litter, biochar locks in moisture and organic and inorganic nitrogen compounds (Gerlach and Schmidt, 2012).

The nitrogen adsorption and the continuous drying of the litter deprive the microbial pathogens of their nutrient base and reduce toxic emissions of ammonia. After just a few days, a significant reduction in coop odour can already be noticed ((Gerlach and Schmidt, 2012). With the lowering of the moisture content and ammonia contamination the risk of footpad diseases decreases. Existing infections begin to heal. Animals' resistance increases, with a positive effect on their vitality, egg production and final body weight. Biochar's high adsorption capacity makes it possible to reduce the use of lime in the litter, thereby reducing the pH of the litter and manure, which in turn reduces ammonia emissions (Gerlach and Schmidt, 2012).

2.11.4: Veterinary Use of Biochar

Charcoal has been used in medicine for the past 100 years due to its ability to adsorb most poisons (Chyka and Seger 1997). Around the mid-1970s, activated charcoal was accepted as an antidote in adsorption and elimination of a variety of medications. Charcoal generally refers to the carbonaceous residue of wood, coconut shells and various industrial wastes left after heating organic matter in the absence of oxygen. Charcoal is an adsorbent for many toxins, gases, drugs, fat and fat-soluble substances without any specific action (Kutlu *et al*., 2001).

The petitioned and principal veterinary use is as an antidote to toxic substances and analogous medical applications include use as a detoxifier. It is regarded as the poison antidote of choice (Aiello, 1998) and the universal antidote to toxic substances (Kanzler, 1995). There is no reported over dosage or acute toxicity (Plumb, 1999). Activated charcoal is very effective against both natural and synthetic toxins. It is reported by Huwig *et al*. (2001) that activated carbon is effective in eliminating many mycotoxins

which include aflatoxin, fumonisins, ochratoxin A, trichothenes, and zearalenone. Toxin occurring naturally from plants is also removed by activated charcoal treatment or supplementation (Bisson, *et al*., 2001).

Activated carbon can also be used to eliminate synthetic pesticides from animals that might contaminate milk or meat. Treatment with activated carbon when using certain parasiticides can help reduce the residual levels in flesh and fatty tissue (Crookshank, *et al*., 1972). Finally, activated charcoal is used to treat animals for drug overdoses (Haddad and Winchester, 1983), with efficacy established on pigs (Lipscomb and Widdop, 1975), dogs (Widdop *et al*., 1975), and rabbits (Galloway and Liu, 1980).

2.12.0: Other Feed Additives That Increases Feed Utilization

Bentonite is a clay mineral with strong colloidal properties and the ability to rapidly absorb many times its volume of water. Clays are often added to an animal's diets as a stabilizer, lubricant or agglomerate to improve feed manufacture (Angulo *et al*., 1995). Nutrient digestibility and enzymatic activity of gastrointestinal secretions has been improved by addition of clay to broilers and pig feedstuffs (Alzueta *et al*., 2002). Bentonite has been used effectively as a feed additive in poultry rations, with the swelling of bentonite causing a reduction in the rate of feed transit through the digestive tract, permitting time for more effective utilization (Damiri *et al*., 2010). Addition of sodium bentonite was effective in ameliorating the negative effect of aflatoxins in poultry diet (Moghaddam *et al*., 2008).

The toxin is prevented from being absorbed by the digestive tract and the bound aflatoxin is then excreted (Pasha *et al*., 2007). The supplementation of poultry rations with Cu-montmorillonite clay has been reported to result in reduced total viable counts of Escherichia coli and Clostridium in the small intestine and caecum of chicks (Xia *et al*., 2004). Clinoptilolite is a common form of natural zeolite. Zeolites are crystalline, hydrated aluminosilicates of alkali and alkaline earth cations.

Zeolites have cation exchange properties and are capable of trapping molecules within their pores (Eleroğlu *et al*., 2011).

For example, the porosity, particle and crystal size of the zeolitic material and its degree of aggregation determine the rate of access of ingesta fluids during passage through the GIT (Papaioannou *et al*., 2002). Average daily live body weight gain and feed conversions in broilers have been improved with dietary inclusion of zeolites (Fethiere *et al*., 1994). Zeolite feed amendment has also been reported to increase egg production (Olver, 1983) and have positive effects on egg weight and internal egg quality (Papaioannou *et al*., 2002). Papaioannou *et al*. (2002) reported zeolite feed amendment to be associated with a reduction in the rate of passage of feed through the digestive system, and an associated reduction in feed intake (Fethiere *et al*., 1990) resulting in better FCR. However, factors including the type of zeolite, its purity, physiochemical properties, and the supplementation level used in the diets may impact the performance effect.

Chemically modified natural zeolites have been associated with bactericidal effects on pathogenic organisms in the guts of birds. Table 19 indicates various Non-nutritive feed additives commonly used in poultry feed formulations helps in disease control.

A reduction in mortality of broiler chickens and reduced viable counts of *Salmonella enteritidis* and *Escherichia coli* in the proximal and distal gut were associated with inclusion of zeolite in feed, (Olver, 1983). Zeolite can be modified chemically with organic cations resulting in increased hydrophobicity of the mineral surface, increasing its adsorptive capacity to certain molecules, and resulting in increased bactericidal effects against *Escherichia coli* and its toxins (Daković *et al*., 2005).

The role of SSF enzymes as a means to utilize the fibre component in poultry diets has been gathering significant momentum, and much has been done to demonstrate the efficacy of such technologies.

Rutz *et al.*, (2007) report that a natural SSF enzyme complex is extremely effective in releasing energy and reducing gut viscosity, both of which are important considerations when utilizing by-products such as wheat bran in animal diets while maintaining performance. The future, however, will see next-generation SSF products that will be tailored to the by-product used. Different micro-organisms and strains will be screened and selected for maximum fibre utilization for particular by-products. Table 19 indicates various Non-nutritive feed additives commonly used in poultry feed formulations helps in disease control.

Table 19. Non-nutritive feed additives commonly used in poultry feed formulations

	Examples	Uses
Enzymes	Xylanases, ß-glucanases, phytase	To overcome the anti-nutritional effects of arabinoxylans (in wheat and triticale), ß-glucans (in barley) or phytate (in all plant feedstuffs); to improve the overall nutrient availability and feed value.
Antibiotics	Avilamycin,virginiamycin, zinc bacitracin, avoparcin,tylosin, spiramycin	To control gram-positive, harmful bacterial species in the gut; to improve production efficiency; as a prophylactic measure against necrotic enteritis.
Coccidiostats	Monensin, salinomycin, narasin	To prevent and control the clinical symptoms of coccidiosis.
i.Direct-fed microbials	Probiotics Fructo oligosaccharides (FOS), mannan oligosaccharides (MOS)	To provide beneficial species such as *lactobacilli* and *streptococci.*
ii. Prebiotics iii Organic acids	Propionic acid, diformate	To bind harmful bacteria
vi Botanicals	Herbs, spices, plant extracts, essential oils	To lower gut pH and prevent the growth of harmful bacteria
v.Antimicrobialproteins/peptides	Lysozyme, lactacin F, lactoferrin, α-lactalbumin	To prevent the growth of harmful bacteria

Source: **Ravindran** (2003)

2.13.0: Inference from Literature Review

Poultry is a term used to describe birds kept for profit (Oluyemi and Roberts, 1988). Many countries including Ghana have adopted intensive poultry production as a means of solving protein problems (Smith, 1990).

Despite increase in the interest of poultry production over the past decade, feed cost which accounts for about 75% of the entire outlay in poultry farming, has been one of the

major problems facing the industry (Kekeocha, 1984). To achieve cost effectiveness, many researchers have exploited the use of non-conventional feedstuffs such as cassava (Oluyemi and Roberts, 1979), mucuna beans (Mesuna, 2004), blood (Donkoh *et al*, 1998) and agro-industrial by products such as oilseed cakes (Nelson, 1998). One plant resource of interest as a non-conventional feedstuff that has been identified is false yam (Dei *et al.*, 2011).

The raw false yam tuber contains about 10-15% starch, while the flour has approximately: water 11.7%, protein 10.3%, carbohydrate 74.5% and ash 2.8%. The tuber contains a bitter principle, reported to be a gum resin, is present in quantities ranging from 0.9-2.8% (NRI, 1987). Some benefits derived from the said plant includes: serves as food source for both humans and animals and medicinal uses.

The seeds and tubers are products which are high in carbohydrate, thus can serve as alternative dietary source of energy for broilers (Dei *et al*., 2011a). The False yam seeds and tubers contain bitter substances (gum resins) and cannot be eaten unless processed (Fay, 1991). Therefore, there is a need for it to be properly processed to ameliorate the adverse effects of the anti-nutritional factors such as resins.

Previous report indicated that, processing of false yam tuber such as soaking in water (Dei *et al.*, 2011) and soaking with additives like Saltpeter (Dei *et al.*, 2015) has been recommended to improve the nutritive value for broiler chickens and also reduce the cost of feeding.

Gerlach and Schmidt (2012) described biochar as toxin binder. Hence its addition to false yam tuber meal will help bind residual toxins in the tuber, thereby improving its nutrient

value for poultry. According to Yarrow (2015), biochar has the potential of increasing the nutrient adsorption, retention and transport to improve the liver-intestine circuit.

Feeding soaked false yam tuber meal based diets to laying chickens affected egg production at 5% level of inclusion (Mohammed and Dei, 2013).

CHAPTER THREE

3.0: Materials and Methods

3.1.0: Location and Duration of experiment

The experiment was carried out at the Poultry Unit of the Department of Animal Science, Faculty of Agriculture, University for Development Studies, Nyankpala campus, Tamale. The site is located in the Guinea savanna zone on latitude 9° 25' 41'' N and longitude 0° 58' 42'' W at altitude 183m above sea level (SARI, 2001). Nyankpala has an annual mean rainfall of about 1160 mm (NAES, 1988). Average temperature of the study area is about 15 °C minimum and 42 °C maximum with annual mean temperature of 28.3 °C and a mean annual day time humidity of 54% (SARI, 2001). The experiment lasted for a period of 20 weeks (16th February to 4th July, 2016).

3.2.0: Source and processing of false yam tuber and biochar

The false yam (*Icacina oliviformis*) tubers were harvested (dug up by the use of a pick axe and hoe) in the Nyankpala environs. It was then peeled using knife and chopped into a particle size of between1-2 cm with the help of a knife. The chopped pieces were soaked in tap water for twelve days in the ratio one part of the fresh tuber to two parts of water with the water changed every three days. After soaking, the chopped tubers were sun dried on a concrete floor to a dry matter content of about 90 % and then milled into gritty flour and bagged for use. The product was labeled SFYTM.

The charcoal used in this study was purchased from the Tamale Central market, crushed using stones, and milled into gritty flour to serve as the biochar for use during the experimentation. It was labeled BC.

3.3.0: Chemical analysis of soaked false yam tuber meal and experimental diet

Samples of SFYTM for the purpose of this work were not analyzed for its amino acid content and terpenic constituents due to funds limitation. However, the chemical composition of the SFYTM (Table 19) as determined by Dei *et al*. (2011a) was used for dietary formulations, since the false yam tubers were harvested in the same locality. Samples of the experimental diet were analyzed for their proximate composition (Table 20) using procedures described by AOAC (2000).

Table 20. Nutrient composition of SFYTM (%DM)

Components	**Amount (%)**
Crude protein	3.63
Ether extract	1.10
Neutral detergent fiber	23.14
Ash	1.69
Starch	70.33
Gross Energy (MJ/kg DM)	14.27
Essential Amino Acids	
Methionine	0.01
Lysine	0.24
Threonine	0.07
Tryptophan	0.05
Arginine	0.08
Isoleucine	0.08
Macro-elements	
Calcium	0.57
Phosphorus	0.04

Source: Dei *et al* (2011a)

3.4.0: The experimental diet formulation

Five (5) experimental diets were formulated using the Linear Programm Method (LPM) as shown in Table 21, 4%SFYTM+3%BC, 6%SFYTM+3%BC and 8%SFYTM+3%BC were the diets containing soaked false yam tuber meal at 4%, 6% and 8% inclusion levels respectively with 3% BC added. Diet with 0%SFYTM and 0%BC served as the control diet (no false yam, no BC). In accordance with Casey (2007), 3% BC is the level of BC recommended in the diet of broiler chickens. The processed false yam tuber meal was used to replace the maize on percent basis. The diets were formulated to have similar crude protein and caloric values as recommended by NRC (1994) for layer chickens (Table 21).

Table 21. Composition of experimental diets for layer chickens (49 – 68weeks of age)

INGREDIENTS (%)	Control diet	4% SFYTM+ 0%BC	4%SFYTM+ 3%BC	6%SFYTM+ 3%BC	8%SFYTM+ 3%BC
Maize	60.00	57.60	57.60	56.40	55.20
SFYTM	0.00	2.40	2.40	3.60	4.80
BC	0.00	0.00	3.00	3.00	3.00
Soybean meal	19.20	19.20	19.20	19.20	19.20
Wheat bran	6.00	6.00	6.00	6.00	6.00
Oyster shell	9.80	9.80	9.80	9.80	9.80
Layer concentrate*	5.00	5.00	5.00	5.00	5.00
Calculated nutrient composition (%)					
Crude protein	16.00	16.00	16.00	16.00	16.00
Calcium	4.10	4.10	4.10	4.10	4.10
Phosphorus	0.48	0.48	0.47	0.47	0.46
ME(MJ/Kg)	11.19	11.16	11.16	11.15	11.13

Composition of layer concentrate: ME (kcal/kg) 1950; Crude Protein 30%, Crude Fat 4.5%, Crude Fibre 7.5%, Lysine 1.65%, Methionine 2.30, Methionine + Cysteine 2.80%.

Table 22. Analyzed proximate composition of experimental diets (as fed basis)

Parameters (%)	Control diet	4%SFYM + 0%BC	4%SFYTM +3%BC	6%SFYTM+3 %BC	8%SFYTM+ 3%BC
Dry Matter	93.25	92.75	93.25	92.75	93.25
Crude Protein	16.74	14.62	14.85	15.06	14.61
Crude Fibre	4.15	3.59	3.04	2.52	5.15
Ether Extract	2.34	2.32	2.80	2.32	2.80
Ash	9.56	8.81	7.23	11.14	8.86
NFE	54.39	56.69	59.05	55.00	55.53

NFE-Nitrogen Free Extract.

3.8.6: Proximate analytical procedure

Table 22 shows the chemical composition of the experimental diets. Samples of treatment diets and dried faeces were duplicated and analysed for proximate components in accordance with standard methods described by the Association of Official Analytical Chemist AOAC (2000) and the values used to compute apparent nutrient digestibility as indicated below.

Apparent digestibility = (Nutrient consumed – Nutrient excreted in faeces) *100 / Nutrient consumed

3.8.6.1: Moisture

Moisture was calculated by the loss in weight that occurs when a sample is dried to a constant weight in an oven. 2 g each of feed and feacal samples were weighed into a silica dish of known weight. Sample were dried in an oven for 105 ^{o}C for 24 h afterwards and cooled in a desiccator and weighed. This process continued until a constant weight was achieved.

$$\% \text{ Moisture} = \frac{(\text{wt of sample}) + (\text{dish before drying}) - (\text{wt of sample}) + (\text{dish after drying})}{(\text{Wt of sample taken})} \times 100$$

Due to the large variability of water content of feed and feaces, they are usually related for their nutrient content on moisture free or dry matter (DM) basis.

% DM = 100 - %Moisture.

3.8.6.2: Ether Extract

The ether extract of a feed or feacal matter denotes the percentage fat and oil in the feed or the feacal samples. The Soxhlet apparatus was the equipment used for the determination of ether extract. It consists of 3 unique features.

i. An extractor: comprising the thimble which holds the sample

ii. Condenser: for cooling and condensing the ether vapour and a

iii. 250 ml flask

Method: 150 ml of an anhydrous diethyl ether (petroleum ether) of boiling point of 40-60 ^{0}C was placed in the flask. 2-5 g of the sample was weighed into a thimble and the thimble plugged with cotton wool. The thimble with content was placed into the extractor; the ether in the flask was then heated. As the ether vapour reached the condenser through the side arm of the extractor, it condensed to liquid form and drop back into the sample in the thimble, the ether soluble substances were dissolved and were carried into solution through the siphon tube back into the flask. The extraction continued for at least 4 h. The thimble was removed and most of the solvent were distilled from the flask into the extractor. The flask was disconnected and placed in an oven at 105 ^{0}C for 4 h, cooled in desiccator and weighed.

S% Ether extract = (Weight of flask + extract – tare weight of flask/Sample Weight) *100

3.8.6.3: Ash

Ash basically is the inorganic residue obtained by burning off the organic matter of feedstuff at 400-600 ^{0}C in muffle furnace for 4hrs. Two (2) g of the sample was weighed into a pre-heated crucible. The crucible was placed into muffle furnace at 400-600 ^{0}C for

4 h or until whitish-grey ash is obtained. The crucible was afterwards placed in the desiccator to cool then weighed

% Ash = (weight of crucible + ash – weight of crucible/Sample Weight) *100

3.8.6.4: Crude Protein

Determination of crude protein was by measuring the nitrogen content of the feed and faecal matter multiplied by a factor of 6.25, because most protein was assumed to contain 16% nitrogen. Crude protein was determined using the kjeldahl method**.** The procedure includes: Digestion, Distillation and Titration.

2g of the sample was weighed into kjeldahl flask and 25 mls of concentrated sulphuric acid, 0.5 g of copper sulphate, 5 g of sodium sulphate and a speck of selenium tablet were added for digestion. Heat in a fume cupboard was applied slowly at first to prevent undue frothing, and continued to digest for 45mins until the digesta became clear pale green. It was left until completely cooled and rapidly added 100 mls of distilled water. The digestion flask was rinsed 2-3 times and added the rinsing to the bulk.

Markham distillation apparatus was used for distillation. The distillation apparatus was steamed up and about 10 mls of the digest was added into the apparatus via a funnel and allowed to boil. To prevent the loss of ammonia, 10 mls of sodium hydroxide was added from the measuring cylinder. It was distilled into 50 mls of 2 % boric acid containing screened methyl red indicator.

The alkaline ammonium borate formed was titrated directly with 0.1*N* HCl. The titre value which was the volume of acid used was then recorded. The volume of acid used was substituted into the formula as shown below

$$\% N = \frac{\{14 \times VA \times 0.1 \times w\}}{1000 \times 100} \times 100$$

VA = volume of acid used w= weight of sample

% Crude protein = % N x 6.25

3.5.0: Experimental birds

The birds for the experiment were 250 ISA brown layers obtained from Dormaa in the Brong Ahafo Region of Ghana. At 49 weeks of age, 250 birds of similar weights were selected and divided into groups of ten each. Each cage of the ten birds received one of the five experimental diets for the twenty weeks of the experimental period.

3.6.0: Experimental design

Completely Randomized Design (CRD) was used for the experiment and each dietary treatment had five replicates. Each replicate consisted of ten birds randomly assigned to each treatment diet (Table 21).

3.7.0: Management of Birds

The birds were housed in deep litter pen (1.8 m x 0.9 m= 0.11m^2/bird). The birds were fed and watered *ad-libitum*. Light was also provided 24 h using 100watt onion bulbs. Each replicate was provided with one plastic feeding trough and 10-litre capacity plastic drinker. Eggs were picked and weighed from each replicate every day at 4:00 pm using a

digital electronic kitchen scale (SP-10016204-Chinese made) and data recorded. Littre material (rice husks) was changed very two weeks.

3.8.0: Feeding and Digestibility Trials

The experiment was carried out so as to assess the effects of the experimental diets on egg production. These are feeding trial and nutrient digestibility trial.

3.8.1: Feeding trial

Feeding trial was carried out to investigate the relative effects of the composition of the different diets (new feed material for example soaked false yam tuber meal with biochar) on egg production of chickens. These birds were allocated to the experimental diets, with appropriate design and number of treatments and replications during the feeding trial. The data collected were on parameters which include feed intake, hen day production and haematological indices as well as serum biochemistry.

3.9.0: Data collection on egg laying performance

3.9.1: Feed intake

Feed consumption or intake was measured weekly. The feed consumed per bird per replicate was obtained by subtracting feed leftover at the end of the week from the total feed supplied for the week. It was then divided by the total number of birds in a replicate and number of days in the week and then multiplied by thousand (1000) to obtain mean feed intake per bird per day in grams. The feed was weighed using an electronic weighing scale (Jadever, JPS-l050).

3.9.2: Hen-day egg production

Hen-day egg production was determined by taking the number of eggs laid in a day as a percentage of number of hens in a pen. The mean of weekly hen-day production was also recorded.

3.9.3: Average egg weight

The weights of eggs were recorded daily. Average egg weight per replicate was obtained daily by weighing each egg from each pen respectively. An electronic kitchen scale (Master Chef sp-10016204 Model) was used in weighing the eggs in each replicate.

3.9.4: Feed conversion efficiency

It is the amount of feed converted into eggs. This was determined by feed-to- egg mass ratio. This was determined by dividing the mean feed consumed per bird by the mean egg mass per bird during the same period.

3.9.5: Feed cost

Unit price (kg) of each ingredient was determined by dividing the price by the quantity in a bag or container. Unit price of each ingredient was multiplied by the quantity of that ingredient in the diet. These were added up to get cost per 100 kg feed. This was then divided by 100 to get cost per kg feed. Feed consumption per bird in a replicate was calculated and multiplied by cost of feed per kg to get cost of feed consumed.

The cost incurred by SFYTM and BC were only as a result of harvesting, processing and purchasing of the materials which was determined by the minimum working hours per day and minimum daily wage per person per day. The minimum daily wage was then

multiplied by the number of workers used. The actual cost of SFYTM and BC in kg was multiplied by the amount of SFYTM and BC used in the diet.

3.9.6: Egg mass

This was obtained by multiplying the average egg weights in grams by the hen day egg production.

3.9.7: Mortality

Records of mortality were taken as and when it occurred. Six mortalities were recorded at the end of the experiment, representing a percentage total of 2.4. Out of these, four were recorded from the control diet and the other two from 4 % SFYTM+0 % BC the treatment diet.

3.10.0: Economic analysis of experimental diets

Wood charcoal, which was used as BC with the experimental diet (SFYTM), was purchased from the common market at Tamale Central market at the estimated cost below;

1 man-day= 8 h= GH₵ 8.00 (minimum wage, 2016)

One laborer was contracted to help in the processing of the BC and used 12 h

However, 8 h = **GH₵ 8.00**

12hrs = **X₵**

X= (12 x 8.00)/ 8

X = **GH₵ 12.00**

Cost of transportation and milling = **GH₵ 4.00**

Cost of 2bags of charcoal = **GH₵ (30 x 2) = 60**

Therefore, total cost = **GH₵ 12.00 + GH₵ 4.00 + GH₵ 60.00 = GH₵ 76.00**

Quantity of BC realized after processing = **78kg**

Cost per kilogram BC = **GH₵ 76.00/78kg = GH₵ 0.97/kg**

Therefore, the estimated cost of BC = 97 pesewas/kg

The experimental material (**false yam tuber**) was not bought. The cost incurred was as a result of harvesting and processing.

Estimated cost of the SFYTM

1 man-day= 8hours= GH₵ 8.00 (minimum wage, 2016)

5 labourers used 72 h to harvest, peel, chop into pieces and soak the false yam. The cost was estimated as follows:

If 8 h = **GH₵ 8.00**

72 h = **X₵**

X= (72 x 8.00)/ 8

X = **GH₵ 72.00**

Cost of water used = **GH₵ 10.00**

Cost of transportation and milling = **GH₵ 10.00**

Therefore, total cost = **GH₵ 72.00 + GH₵ 10.00 + GH₵ 10.00 = GH₵ 92.00**

Quantity of SFYTM realized after processing = 145 kg

Cost per kilogram SFYTM = **GH₵ 92.00/145 kg = GH₵ 0.63/kg**

Therefore, the estimated cost of SFYTM = 63 pesewas/kg

3.10.1: Feed cost per kilogram diet

Quantities of ingredients used in preparing a 100 kg feed were multiplied by their respective unit prices to give the cost of a 100 kg feed. This was then divided by 100 to get the unit cost (GH¢) of each diet.

3.10.2: Total feed intake per bird

Total feed intake per bird was obtained by multiplying mean feed intake per bird per day per replicate by the duration of the experiment in days (140 days) to get total feed intake per bird.

3.10.3: Total feed cost per bird

Total feed cost per bird was obtained by multiplying the unit cost of feed (feed cost/ diet) by the total feed consumed per bird.

3.10.4: Feed cost per egg

Feed cost per egg was calculated by dividing the quantity of feed consumed for a period by the number of eggs collected over the same period to get feed cost per egg.

3.8.2: Digestibility Trial

Samples of the experimental diets were used in a digestion trial to determine the apparent digestibility of the feed samples in terms of dry matter, crude protein, crude fiber, ash and ether extract.

3.8.3: Experimental design for digestibility trial

In a Completely Randomized Design, 25 hens at 69 weeks of age were used in the digestibility trial. The hens were randomly assigned to 25 cages with one hen per cage (0.4 mx 0.3 m=0.12 m^2). Each hen received one of the five dietary treatments which were further replicated five times.

3.8.4: Management of birds for digestibility trial

Allocated dietary treatment feeds were fed to the birds for the period of 13 days. The first eight days constituted the preliminary stage of the trial, and the last five days was used for data collection. Feed and water were provided *ad libitum* during the period. Light was also provided 24 h using 100 watt incandescent bulbs.

3.8.5: Data collection for the digestibility trial

Known quantities of diets were measured and supplied to the hens on daily bases. The faecal matter was collected in plastic sheet placed beneath the wire-mesh floor of the cages using the Total Collection Method.

Faeces were collected daily from birds in each replicate cage and oven dried (60 °C for 48 h). At the end of the trial, collected oven dried samples were pooled into one sample per treatment weighed. The samples were grounded and stored in air-tight plastic containers for analysis.

3.11.0: Collection of blood sample

Two birds from each replicate were randomly selected for blood sample collection at the end of the study. The selected birds were restrained and 2 ml of blood drawn from their wing veins with a syringe and needle. The collected blood from each bird was emptied

into test tubes and labeled. The test tubes containing ethylene diaminetetra acetic acid (EDTA), an anticoagulant which was mixed gently with the blood to prevent blood clot was used for haematological analysis for PCV, RBCs, Hb, MCV, MCH, MCHC and WBCs. The other set of tubes without the EDTA was used for the serum biochemistry analysis.

The Automated Haemo Analyzer (Centro II) was programmed with anticoagulated blood samples for haemo analysis. Drabkins solution was siphoned with blood samples to generate haemoglobin values spectrophotometrically which were used automatically for values of other haemo parameters (PCV, MCH, MCV, MCHC). Turks solution was used with the analyzer to count the whole blood cells. Each parameter has its own reagent and ranges with their specific controls to used.

3.11.1: Packed cell volume (PCV)

The hematocrit or packed cell volume is an essential part of the cell blood count. It is the measurement of the percentage of red blood cells (RBCs) in the circulatory system. Evaluation of the hematocrit is essential for determining the state of health of a bird and can be easily accomplished (Sakas, 2002).

3.11.2: Red blood cell count (RBCs)

Red blood cell count is a blood test giving a true picture of the quantity of red blood cells present in a blood sample expressed in millions micro per litter (**10^6µl)**.

3.11.3: Haemoglobin (Hb)

This is the iron-containing oxygen transport metalloprotein in the RBC of all vertebrate with the exception of the fish family as well as the tissues of some invertebrates (Maton

et al., 1993). It represents the number of grams of haemoglobin contained in a deciliter of blood. It carries oxygen from the respiratory organs to the rest of the body.

3.11.4: Mean corpuscular volume (MCV)

Mean corpuscular volume is the average size of the red blood cells in circulation. It is expressed in fentolitre (fl) or 10^{-15}L

3.11.5: Mean corpuscular haemoglobin (MCH)

Mean corpuscular haemoglobin denotes weight of haemoglobin found in the circulating red blood cell.

3.11.6: Mean corpuscular haemoglobin concentration (MCHC)

Mean corpuscular hemoglobin concentration (MCHC) is of a measurement of the concentration of hemoglobin in a given volume of packed red blood cells (Zheng, 2015). It provides the average concentration of haemoglobin in the RBCs expressed as a percentage.

3.11.7: Leukocyte differential counts

According to Operational Medicine (2001), the white blood cell differential count determines the number of each type of white blood cell, present in the blood. It can be expressed as a percentage (relative numbers of each type of WBC in relationship to the total WBC) or as an absolute value (percentage x total WBC).

3.11.8: Total white blood cells (WBCs)

White blood cells, also called leukocytes, are an important part of the body's defense against disease. In response to infection the WBC count typically increases. Therefore,

measure of the WBC count can give an indication if there is infection or inflammation occurring (Sakas, 2002)

3.11.9: Estimation of Total Protein, ALP (Alkaline Phosphatase), ALT (Alanine Transaminase) and AST (Aspartate Transaminase).

The Random, Access, Fully-Automated "Walk Away" Clinical Chemistry Analyzer (Flexor XL, Vital scientific, Netherlands) was used for the serum biochemistry analysis. Before the start of each test, the machine was calibrated using a multi-calibrator (ELICAL 2 Multiparametric Calibrator, CALI – 0550). Two separate controls were also run on the machine and these were the ELITROL I Normal Mutiparatric Control (CONT – 0060) and ELITROL II Abnormal Multiparametric Control (CONT – 016). Total Protein, Albumin, ALP, ALT, AST were all measured spectrophotometrically. The concentration of the parameter to be measured depends on its quantity and colour intensity development when sample is mixed with its reagents. Light absorbance through the colour solution determines its concentration (sample). The procedure is as follows:

Blank samples were first measured in the spectrometer to give zero value. Sample controls were also measured to ascertain the performance of the spectrometer with its known values.

The controls and the blanks were commercially supplied for every parameter that was to be measured. The samples were then measured using micro curvettes that were inserted into the spectrometer and values displayed digitally. Each measurement goes with its filter with a known wavelength (nm).

3.11.9.1: Total Protein

This measures the amount of protein in the blood. The two main proteins found in the blood are globulins and albumin.

Estimation of total protein in this study is based the modifications of Gornall *et al.*,(1949). Protein in serum forms a blue coloured complex when reacted with cupric ions in an alkaline solution. The intensity of the violet colour is proportional to the amount of proteins present when compared to a solution with known protein concentration. It is measured using a spectrometer.

3.11.9.2: Albumin test

According to the Association for Clinical Biochemistry, (2012) albumin is the major plasma protein. In the reaction, the albumin combines with Bromcresol Green (BCG) or Bromcresol Purple (BCP) reagent to produce a blue-green colour or form a complex respectively. The system monitors the change in absorbance at respective rates of 628 nm (BCG) and 600 nm (BCP). The change in absorbance or the intensity of colour produced is directly proportional to the concentration of albumin in the sample.

3.11.9.3: Globulins Test

Globulins are a group of proteins in the blood stream that help to regulate the circulatory system. Abnormal globulin level can lead to serious health problem. Globulin levels in the blood are directly linked with the levels of albumin in the body. It is a calculated parameter which is given by: **Globulin**=Total protein - Albumen

3.11.10: Alanine Transaminase

Alanine Transaminase (ALT) is an enzyme mainly found in the liver. The ALT test measures the level of ALT in the blood. Consistently high levels of ALT in the blood can be a sign of liver damage.

3.11.11: Aspartate Transaminase

Aspartate Transaminase (AST) is an enzyme found in large amounts in the liver and other parts of the body. The AST test measures the level of AST in the blood. High levels of AST can be a sign of liver damage.

3.11.12: Alkaline Phosphatase

Alkaline Phosphatase (ALP) is an enzyme found in large amounts in the liver, bile ducts, and other parts of the body. The ALP test measures the level of ALP in the blood. High levels of ALP can be a sign of liver or bile duct damage.

3.12.0: Statistical analysis

The parameters in this trial were subjected to analysis of variance (ANOVA) for Completely Randomized Design (CRD) using GenStat, 3rd version (Payne, 2005). Significant differences among treatment means were separated using least significant difference (LSD) and values were considered significant at ($P<0.05$).

CHAPTER FOUR

4.0: RESULTS

4.1.0: Apparent digestibility of experimental diets

Results of the effect of varying levels of SFYTM with BC on apparent nutrient digestibility of the experimental diets by laying chickens are shown in Table 23.

Table 23. Effect of varying levels of SFYTM with BC on apparent nutrient digestibility

Parameters (%)	Control diet	4%SFYTM+ 0% BC	4%SFYTM + 3% BC	6%SFYTM + 3% BC	8%SFYTM + 3% BC	±SED	P-value
Dry Matter	80.69^{a}	79.11^{b}	78.33^{c}	78.08^{d}	76.17^{e}	0.003	<0.001
Crude Protein	70.59^{a}	63.53^{d}	68.45^{b}	68.32^{b}	66.57^{c}	0.756	<0.001
Crude Fibre	56.60	50.10	56.70	57.30	52.30	4.22	0.380
Ether Extract	83.90	87.80	78.30	81.70	84.10	3.24	0.129
Ash	51.37^{b}	50.92^{b}	46.26^{c}	58.78^{a}	48.86^{bc}	2.222	0.003
NFE	89.10^{a}	87.86^{b}	88.11^{b}	87.28^{b}	85.31^{c}	0.453	<0.001

SED-Standard error of difference, P-probability, means with the same superscripts in a row are not significantly different (P>0.05). NFE-Nitrogen Free Extract.

4.1.1: Dry matter

There were significant differences (P<0.001) in the dry matter digestibility of the experimental diets (Table 23). Dry matter digestibility decreased with increase in the inclusion of SFYTM with the highest (P<0.55) digestion recorded in the control diet.

4.1.2: Crude protein

Protein digestibility was superior (P<0.001) in the control diet over other diets containing SFYTM. The diet with 4% SFYTM without BC recorded the least (P<0.001) protein digestibility of 63.53%. However, within the diets containing 3%BC, 4%SFYTM+3%BC

did not differ (P>0.05) significantly in protein digestibility, and recorded protein digestibility values higher (P<0.001) than the diet containing 8% SFYTM+ 3%BC (Table 23).

4.1.3: Crude fibre

The values recorded for fibre digestibility were similar (P>0.05) for all experimental diets. The highest CF digestibility value was recorded in diet containing 6%SFYTM+3%BC with the diet containing 8%SFYTM+3%BC having the least CF digestibility mean value of 52.30%, (Table 23).

4.1.4: Ether Extract

Generally, EE digestibility was high for all experimental diets. However, there was no significant difference (P>0.005) observed for EE digestibility in all diets tested (table 23).

4.1.5: Ash

Ash digestibility for birds fed both control diet was statistically same (P>0.05) and also similar to birds on diets containing 8%SFYTM+3%BC. Diet containing 4%SFYTM+3%BC was significantly (P<0.05) different from birds fed treatments diets containing 6%SFYTM+3%BC but similar to birds on treatment diets containing 8%SFYTM+3%BC. Birds on treatment diets containing 6%SFYTM however differed significantly (P<0.003) from the rest of the treatments diets (Table 23).

4.1.6: Nitrogen free extract

Digestibility of NFE was significantly (P<0.05) higher for birds on control diet than birds fed diet containing SFYTM with or without BC. However, birds fed diet containing 4%

and 6% SFYTM with or without BC had similar NFE digestibility (P>0.005) and higher digestibility values (P<0.001) than birds fed diets containing 8% SFYTM with 3%BC.

4.2.0: Feeding trial

The effects of varying levels of SFYTM with 3%BC on feed intake and egg laying performance of layers are shown in Table 24.

Table 24. Effect of 3%BC at varying levels of SFYTM on performance of layer chicken

Parameters	Control diet	4% SFYTM+ 0%BC	4% SFYTM+3% BC	6% SFYTM+3% BC	8% SFYTM+3% BC	±SED	P-value
Feed intake (g/b/d)	90.89	91.81	92.31	95.31	89.50	2.859	0.369
Hen-day egg production (%)	67.70[b]	74.60[a]	74.70[a]	77.00[a]	74.80[a]	3.35	0.002
Mean egg weight (g)	56.29	56.74	57.12	57.13	56.49	1.181	0.935
Mean egg mass (g/hen)	38.12	42.41	42.69	43.98	42.30	2.347	0.172
Feed-to-egg mass ratio	2.44	2.18	2.17	2.17	2.12	0.151	0.268
Mortality (%)	0.80	0.40	0.00	0.00	0.00	0.400	0.213

SED-Standard error of difference, P-probability, means with the same superscripts in a row are not significantly different (P>0.05).

4.2.1: Feed intake

There was no significant (P=0.369) difference between control diet and the rest of the treatment diets containing SFYTM with or without BC. Birds fed the control diet had a slightly lower mean feed intake value as compared with birds on 4%SFYTM+0%BC but

higher feed intake than birds on 8%SFYTM+3%BC. Birds fed with diet containing the highest inclusion level of SFYTM (8%SFYTM+3%BC) recorded the lowest feed intake (89.50 g/b/d) whiles the highest (95.31g/b/d) was recorded by 6%SFYTM+3%BC.

4.2.2: Hen-day egg production

There was a significant ($P<0.002$) difference observed in hen-day egg production between birds fed the control diet and those birds fed diet containing SFYTM with or without BC. However, birds fed diets containing SFYTM with or without BC recorded similar ($P>0.005$) hen day egg production (Table 24).

Egg production performance of experimental hens (49-68 weeks) is shown in Figure 2 below.

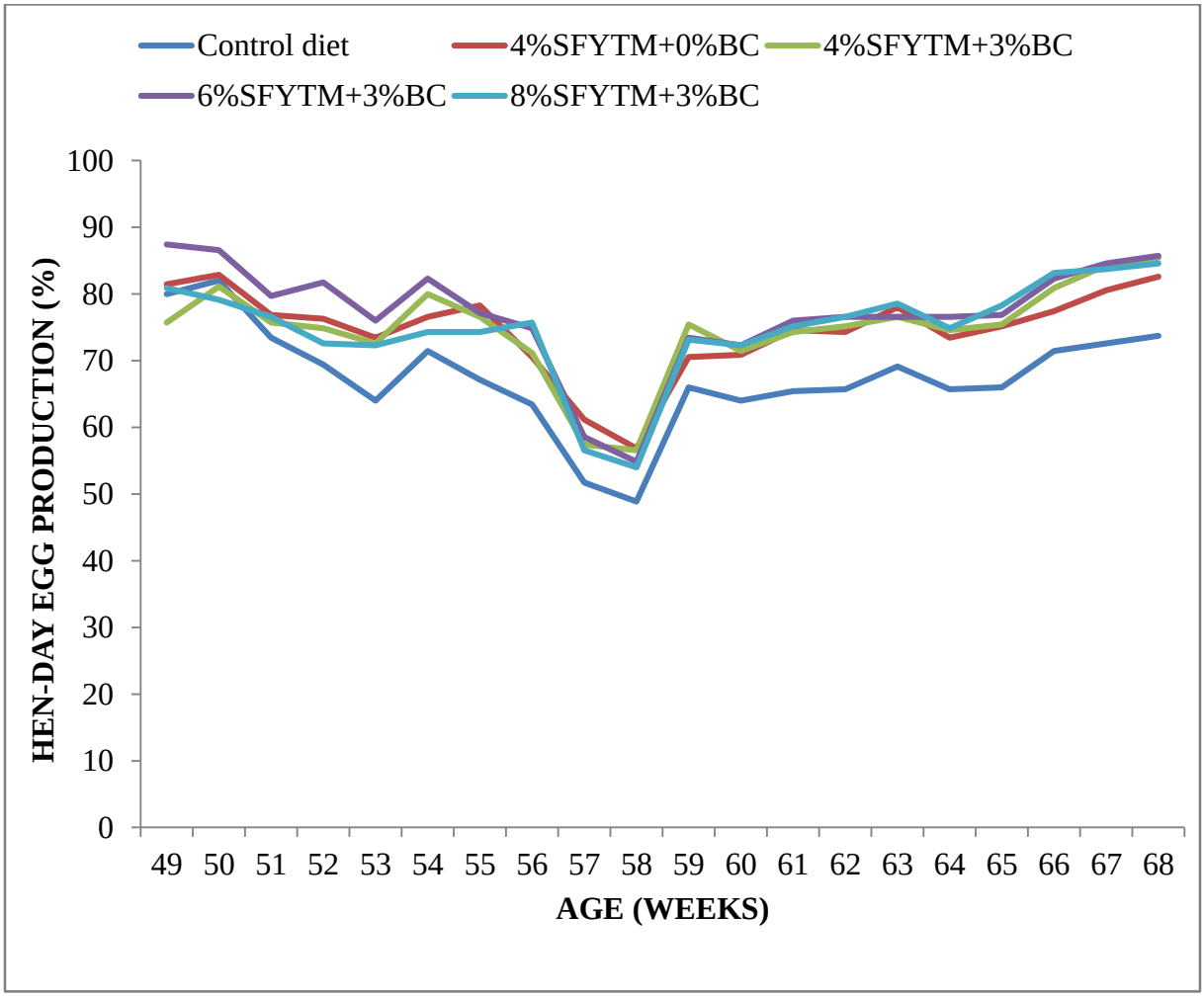

Figure 2: Effect of 3% BC at varying levels of SFYTM on hen-day egg production of laying chickens (49-68 weeks of age)

Egg production during the laying phase as illustrated in figure 2 was higher for birds fed the SFYTM based diets than their counterparts given the control diet throughout the entire 20 weeks of experimentation. Similar hen-day egg production values were recorded for all treatment groups containing the SFYTM.

In general, it was observed that egg production of birds on all the five-dietary treatment had a drastic decline in egg production at 56 weeks (8th week of study) of age which lasted for about two weeks before picking up again at 58 weeks (10th week of study) of age and remained fairly constant to the end of the work (Figure 2).

4.2.3: Mean egg weight

The mean egg weight as indicated in Table 24 did not differ significantly (P>0.05) among the treatment groups. The mean egg weight values recorded in this study ranged between 56.29-57.13g. Birds on the control diet recorded a slightly lower mean value (56.29 g) than those birds on diets containing SFYTM with or without BC.

4.2.4: Mean egg mass

There was no significant (P>0.05) difference between birds fed control diet and those birds fed diets containing SFYTM with or without BC. The mean egg mass recorded in this study ranged between 38.12 g (control diet) and 43.98 g (6% SFYTM +3% BC) (Table 24).

4.2.5: Feed-to-egg mass ratio

Feed conversion (feed/egg mass) efficiency presented in Table 24 was not significantly (P>0.05) different among the experimental groups. Values recorded for feed to egg mass ratios had a minimum value of 2.12 for birds fed 8% SFYTM+3%BC and a maximum of 2.44 for birds fed standard diet.

4.2.6: Mortality

Mortality of birds occurred only in groups of bird fed the control diet and 4%SFYM+0%BC. An overall total of six mortality cases were observed in the course of

the 20 weeks of study. The control diet recorded a total death toll of four birds and 4%SFYTM+0%BC recording two death cases. Post mortem examinations on fresh carcasses revealed liver rupture on the right halves leading to massive haemorrhage from the liver. The inspections done on the carcasses showed some considerable quantity of fat accretion at the abdominal regions. The disease condition was suspected to be Fatty Liver Haemorrhagic Syndrome (FLHS).

4.3.0: Physical egg quality

Table 25. The Effect of 3%BC at varying levels of SFYTM on physical egg quality characteristics

Parameters	Control diet	4% SFYTM+0 %BC)	4% SFYTM+ 3%BC	6% SFYTM+3 %BC	8% SFYTM+3 %BC	±SED	P-value
Albumin height (mm)	10.16	10.08	10.16	9.36	10.12	0.289	0.051
Haugh unit	98.92	100.12	99.48	100.20	99.68	1.450	0.902
Albumin weight (g)	37.80[b]	36.48[b]	38.80[a]	39.60[a]	40.80[a]	1.362	0.045
Yolk weight (g)	14.12	13.04	13.56	12.80	13.60	0.505	0.119
Shell weight (g)	6.96	6.56	7.04	6.72	7.44	0.323	0.109
Shell thickness (mm)	0.34	0.34	0.34	0.34	0.33	0.014	0.977
Albumin ratio (%)	64.22	64.95	65.22	66.94	65.87	1.065	0.158
Yolk ratio (%)	23.97[a]	23.33[a]	22.94[a]	21.71[b]	22.14[b]	0.714	0 .034
Shell ratio (%)	11.81	11.72	11.86	11.37	12.05	0.509	0.747

SED=Standard error of difference, P-probability, means with the same superscripts in a row are not significantly different (P>0.05).

4.3.1: Albumen height

Values recorded for albumen height in this research were similar (P>0.05) (Table 25) for birds fed all five dietary treatments. However, birds fed the control diet recorded a mean value (10.16) than those on the 4%SFYTM + 0% BC which recorded (10.08).

4.3.2: Haugh unit

There was no significant (P>0.05) difference in terms of protein quality between birds fed all five dietary treatments diets. In terms of numerical differences, those birds fed diets containing SFYTM with or without BC tended to have had relatively higher egg protein quality values (99.48- 100.20) than those birds fed control diet (Table 25).

4.3.3: Albumen weight

Birds fed control diet and those on 4%SFYTM+0%BC showed no significant (P>0.05) difference in terms of their mean albumen weight values. It was also observed that, the control diet and 4%SFYTM+0%BC diets were significantly (P=0.045) different from the three remaining treatments diets containing BC. However, mean albumen weight between birds on treatment diets containing BC were statistically same with increasing mean albumen weights values as the inclusion levels of false yam tuber meal increases (Table 25).

4.3.4: Yolk weight

Table 25 showed that, values recorded for yolk weight in this research, for all five dietary treatments were similar. Hence, there were no significant (P>0.05) difference in yolk weight between birds fed both the control diet and those fed remaining treatments. In general, birds on the control diet tended to have recorded a highest mean value of 14.12 g and those birds fed diet containing 6%SFYTM with 3%BC recording a least mean value of 12.80 g.

4.3.5: Shell weight

There were no significant (P>0.05) difference in shell weight between birds fed all five treatment diets. The mean values recorded ranged from a lower limit value of 6.56-7.44 g.

4.3.6: Shell thickness

Shell thickness for birds fed 4%SFYTM+0%BC and control diet were similar and at the same time with those fed diets containing 3%BC. Birds on the 3%BC treatment diets were also same. Hence there was no significant (P>0.05) difference in egg shell thickness between birds fed all five dietary treatments.

4.3.7: Albumen ratio

The albumin ratio which estimate the proportion of albumin to whole egg for birds fed all five treatment diets was similar. However, birds fed 4%SFYTM+0%BC diet recorded a slightly higher value of 64.95 % as compared with birds on the control diet recording a mean value of 64.22 %. Also, treatment diets containing 3%BC had a higher albumen ratio ranging from 65.22-66.95 % as compared with birds on diet containing 4%SFYTM+0%BC. Generally, birds on the treatment diets containing SFYTM had higher albumen ratios 64.95- 66.94 % than birds on the control diet (64.22 %).

4.3.8: Yolk ratio

The yolk ratio estimating proportion of yolk to whole egg was similar (P>0.05) for birds fed the control diet and birds on diets containing 4%SFYTM+0% BC and 4%SFYTM+3%BC. Also, it was observed that, birds on the control diet were

significantly (P<0.05) different from birds on 6%SFYTM+3%BC and 8%SFYTM +3%BC.

4.3.9: Shell ratio

The shell ratio is the proportion of shell to whole egg and this was observed not to vary significantly (P>0.05) between birds fed all five treatment diets in this study (Table 25).

Table 26. Effect of at varying levels of SFYTM 3% BC on haematological parameters of laying chicken (49-68 weeks of age)

Parameter	Control diet	4%SFYM+ 0%BC	4%SFYTM+ 3%BC	6%SFYM+ 3%BC	8%SFYM+ 3%BC	±SED	P-value
Haematocrit (%)	26.86	28.38	26.24	27.90	25.56	2.484	0.784
Haemoglobin (g/dl)	6.74	7.32	6.70	6.94	6.48	0.653	0.758
MCH (Pg)	31.54	32.60	32.18	31.92	31.62	0.882	0.749
MCHC (g/dl)	25.00	25.80	25.60	24.90	25.30	0.55	0.444
MCV (fL)	126.14	126.36	125.56	128.10	124.92	1.742	0.463
MPV (fL)	9.16^{a}	9.58^{a}	8.34^{b}	8.64^{b}	9.06^{a}	0.374	0.031
RBC ($x10^{6}$ml)	2.13	2.25	2.09	2.18	2.05	0.210	0.895
WBC ($x10^{3}$ml)	9.13	8.44	8.10	8.68	10.55	1.786	0.686

SED=Standard error of difference, P-probability, means with the same superscripts in a row are not significantly different (P>0.05). MCH-Mean cell haemoglobin (Pg), MCHC-Mean cell haemoglobin concentration, MCV-Mean cell volume, MPV-Mean platelet volume, RBC- Red blood cells, WBC-White blood cells

4.4.0: Haematological profile of layer chickens

The effects of SFYTM with 3%BC on haematological parameters of layer chickens as shown in table 26 indicated no significant (P>0.05) difference in all haematological parameters measured for all five dietary treatments except for of the mean platelet volume. Mean platelet volume was similar (P>0.05) for birds fed the control diet and birds fed the 4%SFYTM+0%BC as well as the 8%SFYTM+3%BC diets. Also, birds fed the control diet were different significantly (P< 0.03) from birds on 4%SFYTM+3%BC and 6%SFYTM+3%BC dietary treatments.

4.5.0: Serum biochemistry profile of layer chickens

Serum biochemical indices from table 27 showed no significant (P>0.05) difference between all parameters measured under the serum profile of birds fed all five treatment diet aside the alkaline phosphatase. Birds fed control diet, 4%SFYTM+0%BC and 6%SFYTM+3%BC were statistically same even though birds on the control diet recorded a higher numerical value. Also, it was observed that, birds on the control diet were different significantly (P=0.048) from the rest of the other two remaining treatments diets (4%SFYTM+3%BC and 8%SFYTM+3%BC).

Table 27. Effect of 3%BC at varying levels of SFYTM on serum biochemistry parameters of laying chicken (49-68 weeks of age)

Parameters	Control diet	4%SFYM +0% BC	4% SFYTM+3% BC	6% SFYTM+3 %BC	8% SFYTM+ 3%BC	±SED	P-value
Albumin(g/l)	24.90	25.76	23.66	22.62	19.92	3.135	0.408
Globulin(g/l)	35.5	34.2	32.60	29.7	27.0	6.23	0.656
Total proteins(g/l)	60.2	61.5	56.2	52.3	47.5	8.97	0.526
Aspartate transferases(U/l)	146.5	148.5	150.9	136.8	159.2	23.34	0.912
Alanine transferases(U/l)	15.9	10.3	11.0	14.8	12.8	3.48	0.458
Alkaline phosphatase (U/l)	179[a]	107[a]	202[b]	156[a]	233[b]	39.5	0.048

SED=Standard error of difference, P-probability, means with the same superscripts in a row are not significantly different (P>0.05).

4.6.0: ECONOMICS OF FEEDING

From Table 28, feed cost per kg diet decreased slightly (0.62%) with increasing levels of SFYTM in the diets. It was observed that, there was no difference in all treatment diets with respect to the total feed intake. However, birds fed the control diet recorded the highest total feed intake and birds on the 8%SFYTM+3%BC recording the least. Total feed cost and feed cost per egg also showed no significant difference among all five treatments. Feed cost per egg however generally showed lower mean values in diets containing SFYTM with or without BC. There was a reduction of 1.00% comparing the control diet to the rest of the treatment diets containing SFYTM with or without BC.

Table 28. Economic analysis of 3% BC at varying levels of SFYTM on production

Parameter	Control diet	4% SFYTM+ 0%BC	4%SFYTM+ 3%BC	6%SFYTM +3%BC	8%SFYTM +3%BC	SED	P-value
Feed cost/Kg diet	1.62	1.61	1.61	1.60	1.59	-	-
Total feed intake (Kg/hen)	10.23	9.58	9.23	9.53	8.95	0.690	0.449
Total feed cost(GH₵)/ hen	16.60	15.40	14.84	15.25	14.26	1.117	0.343
Feed cost/egg(GH₵)	0.10	0.09	0.09	0.09	0.09	0.008	0.182

SED=Standard error of difference, P-probability, means with the same superscripts in a row are not significantly different (P>0.05).

CHAPTER FIVE

5.0: DISCUSSION

5.1 0: Apparent nutrient digestibility of feed containing SFYTM with BC

The presence of anti-nutritional factors in feedstuffs has been reported to affect feed digestibility and utilization by animals (De Lange *et al*., 2000). False yam has been reported to contain bitter principles (gum resins) which affect digestibility (Fay, 1987). This may be a reason for the decreased apparent digestibility of DM, CP and NFE in the treated diets. It was observed in this study that, as SFYTM inclusion level increased, CP digestibility decreased. It has been reported by Galani *et al*. (2005) that the residual levels of anti-nutritional factors (gum resin) in the feed may have negatively affected CP utilization and amino acid digestibility. Pekel *et al*. (2015) also reported that anti-nutritional factors react with protein, enzymes, or essential amino acids and form various complexes, thus affecting digestibility and nutrient utilization in poultry.

A similar finding was observed by Aziza *et al*. (2013) who fed layers with camelina and flaxseed seed meal which also contain terpenes and observed that the DM and CP digestibility were significantly affected (decreased). When SFYTM was fed to layer at 5%, 7.5% and 10% by Mohammed and Dei (2013) there was also significant reduction in CP digestibility. As reported by Dei *et al*. (2011a) the low levels of CP in SFYTM (Table 20) which was 3.63% will result in decreasing the total CP in the diet as inclusion levels increases.

Addition of BC to the diets containing SFYTM was seen to have improved diet digestibility.

The BC based diet recorded higher digestibility mean values as compared with the 4%SFYTM+0%BC (Table 23) indicating that BC positively affected CP digestibility.

Kutlu *et al*. (2001) reported that biochar is an absorbent for many toxins, gases, fat and fat-soluble substances. Bakr (2008) reported that properties of charcoal as an absorbent had an effect on cell membranes, surface tension and eliminating of gases and toxins in the gastro intestinal tract and therefore improved utilization and absorption of nutrients across cell membranes.

It is reported that, diet supplementation with charcoal increased digestibility for commercial meat chickens and ducks (Kana *et al*., 2010).

5.2.0: Egg production performance

5.2.1: Feed intake

Feeding the birds with diets containing SFYTM with or without BC increased intake as compared to counterparts on the control diets with respect to feed intake. The similarities in feed intake as seen in the entire experimental period indicate the addition of SFYTM with BC enhanced diet palatability comparable to that of the control diet.

Treating the false yam tuber by soaking in ordinary water did remove some anti-nutritional factors and thereby increasing its palatability and hence improving the nutritional quality of the tuber. Previous studies by Dei *et al.* (2011a) showed that soaking reduces the bitterness of the tuber thereby improving feed intake.

Generally, addition of SFYTM to layer diets up to 100g/kg did not affect consumption (Mohammed and Dei, 2013) which confirms the report of Lipstein *et al*. (1975) which indicatethe birds eat similar quantity of feed with similar nutrient composition.

It is also possible that, the treatment with BC contributed to the increase in palatability, as BC is known as a detoxifier and an adsorbent for many toxins, gases, drugs, fat and fat-soluble substances (Kutlu *et al*., 2001). According to Bakr (2008) addition of citrus wood charcoal had considerable improvement in feed intake. It is clear in this study that BC had effect on feed intake because birds on 4%SFYTM+0%BC diet had a lower numerical feed intake value of (91.81 g/b/d) whiles 4%SFYTM+3%BC recorded a higher numerical feed intake value (92.31) even though they were not statistically significant.

5.2.2: Hen-day egg production) HDP

All diets containing SFYTM with or without BC did better than the control diet (Table 24). This could be as a result of the nutritional composition of SFYTM and the positive effect of BC on diet utilization.

As reported by Dei *et al*., (2014a), incorporation of SFYTM up to 40 g/kg in the diets of layer chickens had favourable effect on egg production. The improvement in egg production can be attributed to the lower concentration of the anti-nutritional factors (terpenes) reported by (Vanhaelen *et al.*, 1986; Dei *et al*., 2011) which was not adequate at the levels tested to hinder digestibility and utilization of the diets.

Also, it is known that adding BC to the diet of animals improves their performance. Kana *et al*. (2010) reported that, diet supplement with charcoal resulted in an increased weight, feed conversion ratio in commercial meat chickens and ducks.

Biochar promotes digestion, improves feed efficiency, and thus in particular energy absorption via the feed, toxins such as dioxin, glyphosate, mycotoxins, pesticides and polycyclic aromatic hydrocarbons (PAHs) are efficiently bound by the biochar, thereby

obviating any adverse effects on the digestive system, the intestinal flora will be improved as well as the health, activity and balance of the animals will also be improved, as will egg production (Gerlach and Schmidt, 2012).

The decline in hen day egg production at age 56 weeks was due to a change in layer concentrate due to a shortage of the one in use. Birds will react to any change in diet composition which could lead to the low production performance as observed in the cause of this study (Fig 2). Bain *et al*. (2016) recommended that, rapid change in diet and changes in diet composition should be avoided in keeping layer birds. Also according to Elenwo and Okafor (2014), there are several factors that cause decline in egg production of which changes in diet composition is one of them.

Feed to-egg-mass ratio, expressing the efficiency of diet utilization after digestion into eggs as observed in this study was not significant for all five treatment diets. However, birds on diets containing SFYTM with or without BC compared favourably to those on the control diets. This was evident in egg production as birds on the SFYTM with or without BC based diet tended to have performed better than their counterparts on the control diets. This is in agreement with Dei *et al* 2014a when soaked false yam tuber meal was fed at low dietary levels and Bakr (2008) who said properties of charcoal as an absorbent improved utilization and absorption of nutrients across cell membranes.

5.3.0: Physical egg characteristics

Among many egg quality characteristics, external factors such as egg and shell weights are important in consumers' acceptability of shelled eggs. The similarities observed in

many of the egg internal and external characteristics revealed that, the addition of SFYTM and BC did not have any negative effect on eggs laid.

The high albumin weight recorded by diet containing BC is an indication of better feed utilization. It is reported that, diet supplemented with charcoal results in an increased feed efficiency (Kana *et al*., 2010).

Also, higher albumin weight by diet containing SFYTM and BC than control diet is in harmony with the report of Aziza *et al*. (2013) who also fed layers with two different types of non-conventional feedstuff (camelina and flaxed seed meal) and recorded a higher albumen weight in the treated diet than the control diet.

5.4.0: Mortality

No mortality was recorded for birds that were on diet with SFYTM with BC but some mortality were recorded for birds fed the control diet as well as the 4%SFYTM+0%BC diet (Table 24). This reflected in the value recorded for MPV (Table 26). In the study, higher values of MPV were recorded by birds on the control diet and those on the 4%SFYT+0%BC diet. According to Liu *et al*. (2012), MPV is higher when there is destruction of platelets and this may be seen in inflammatory bowel disease.

Several researches have been conducted over the past decade to better understand the benefits of BC as a feed supplement for broilers. Gerlach and Schmidt (2012) found out that BC deactivated toxins already in the digestive system, positively activating intestinal flora and vitality. Teleb *et al.* (2004) found out that diet supplement with 0.5% BC made from locally available wood overcame the detrimental effects of feeding broilers 30 ppb

aflatoxin by showing reduced mortality rates and improved growth rates when compared to those fed 30 ppb aflatoxin.

5.5.0: Haematological profile and serum biochemistry

Blood biochemical parameters reflect the physiological state of the animal resulting from nutrition, pathogenic factors activity, welfare level or breeding technology (Pavlik *et al*., 2007).

Mean platelet volume is the only parameter that differed in this present study and is a parameter calculated to indicate the presence of diseases. The lower mean platelet volume by diet containing BC as compared to the control diet and 4% SFYTM+0% BC is a clear indication that BC could help in preventing diseases in animals. According to Liu *et al*. (2012) MPV is higher when there is destruction of platelets and this may be seen in inflammatory bowel disease. Not only that, several diseases cause high MPV in blood (Zvetkova and Fuchs, 2017)).

However, the haematocrit values is within reference value for normal chicken reported by Bounous and Stedman, (2000); Gylstorff, (1983) which is 22.00-35.00% and 24.00-43.00% respectively.

Most of the values for haemoglobin were a little less than the reference values which are between 7-13% as reported by Bounous and Stedman, (2000). This may be due to the diet, because the control diet and the remaining diets were lower than the reference value. According to Mohammed and Dei (2013) haematological parameters did not differ when SFYTM was incorporated in the diet of layer chickens. Haematocrit level is similar to

that of Mohammed and Dei (2013) and which is 26-28.75% and 25.56-28.38% respectively.

According to Akusu and Egbunike (1983) factors such as genotype, breed of animals, management or environment, age, diseases, medication and nutrition may have influence on the blood parameters of farm animals.

All serum biochemical parameters measured in this study were not significant except for alkaline phosphatase which was significant. The total protein and albumin values reported in this study were similar to what have been reported by Bubel *et al.* (2015) with birds from 54-65 weeks old. These birds were also fed a plant with medicinal properties as false yam and BC. Alkaline phosphatase (ALP) is a hydrolytic enzyme widely observed in animal tissues. The differences in alkaline phosphatase in the study may be due to other factors than the test material only. This is because the values obtained do not follow any pattern.

According to Stacy (2018), the levels of this enzyme in the blood depend on factors such as age, gender and blood type. Abnormal levels of alkaline phosphatase in the blood could indicate issues relating to the liver, gall bladder or bones. Kidney tumors, infections as well as malnutrition has also shown abnormal level of alkaline phosphatase in blood (Stacy, 2018)

5.6.0: ECONOMICS ANALYSIS OF PRODUCTION

The incorporation of 3% BC at varying levels of SFYTM appeared to have had favourable effect on cost of feeding layer chicken (Table 28). Adding 3%BC at varying levels in diets containing SFYTM tended ($P>0.05$) to reduce total feed cost by 8-14%.

Similar results of feed cost analysis were reported by Mohammed *et al*. (2017) when biochar was incorporated in diets containing false yam seed meal.

Lower total feed cost and total feed intake (6.98 and 5.49kg/bird respectively) was reported by Dei *et al*. (2014) at 4% inclusion level of SFYTM as compared to the current study with BC.

CHAPTER SIX

6.0: CONCLUSION AND RECOMMENDATION

6.1.0: Conclusion

Incorporation of 3%BC in diets containing up to 8% SFYTM significantly decreased apparent crude protein and digestibility.

Addition of 3%BC in diets containing up to 8% SFYTM significantly improved egg production of layer chickens.

Feeding of BC to layer chickens had no adverse effects on their blood profile and no mortality recorded.

The use of 3% BC in diets containing SFYTM tended to have favourable effects on economics of production with 8-14% reduction in total feed cost.

6.2.0: Recommendation

Based on the results of this study, it is recommended that inclusion levels of SFYTM should be increased above 8% to ascertain the level at which 3%BC can effectively improve the utilization of SFYTM.

Also, it is recommended that farmers can use up to 8% SFYTM in layer chicken diet by adding 3% BC.

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APPENDIX

AP1. ANOVA Tables for nutrient digestibility

Variate: ASH					
Source of variation	Df	Ss	Ms	v.r	F pr
Treatment	4	262.101	65.525	8.85	0.003
Residual	10	74.076	7.408		
Total	14	336.177			

Variate: CF					
Source of variation	Df	Ss	Ms	v.r	F pr
Treatment	4	124.99	31.25	1.17	0.380
Residual	10	266.75	26.68		
Total	14	391.74			

Variate: CP					
Source of variation	Df	Ss	Ms	v.r	F pr
Treatment	4	83.3708	20.8427	24.30	<0.01
Residual	10	8.5782	0.8578		
Total	14	91.9490			

Variate: DM					
Source of variation	Df	Ss	Ms	v.r	F pr
Treatment	4	3.243E+01	8.109E+00	9.003E+05	<.001
Residual	10	9.007E-05	9.007E-06		
Total	14	3.243E+01			

Variate: EE					
Source of variation	Df	Ss	Ms	v.r	F pr
Treatment	4	145.65	36.41	2.31	0.129
Residual	10	157.86	15.79		
Total	14	303.50			

Variate: NFE					
Source of variation	Df	Ss	Ms	v.r	F pr
Treatment	4	23.7111	5.9278	19.26	<.001
Residual	10	3.0771	0.3077		
Total	14	26.7882			

AP.2 ANOVA Tables for egg characteristic

Variate: Albumin Height					
Source of variation	Df	Ss	Ms	v.r	F pr
Treatment	4	2.3936	0.5984	2.85	0.051
Residual	20	4.1920	0.2096		
Total	24	6.5856			

Variate: Albumin_ratio_%					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	21.039	5.260	1.85	0.158
Residual	20	56.772	2.836		
Total	24	77.761			

Variate: Albumin weight					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	54.842	13.710	2.96	0.045
Residual	20	92.688	4.634		
Total	24	147.530			

Variate: Egg height					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	0.14582	0.03646	2.49	0.076
Residual	20	0.29280	0.01464		
Total	24	0.43862			

Variate: Egg weight					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	0.078464	0.019616	4.90	0.006
Residual	20	0.080000	0.004000		
Total	24	0.158464			

Variate: Haugh unit					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	5.408	1.352	0.26	0.902
Residual	20	105.152	5.258		
Total	24	110.560			

Variate: Shell ratio					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	1.2559	0.3140	0.48	0.747
Residual	20	12.9644	0.6482		
Total	24	14.2203			

Variate: Shell thickness					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	0.0002282	0.0000570	0.11	0.977
Residual	20	0.0103120	0.0005156		
Total	24	0.0105402			

Variate: Yolk ratio					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	16.403	4.101	3.22	0.0034
Residual	20	25.468	1.273		
Total	24	41.871			

Variate: Yolk weight					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	5.3536	1.3384	2.10	0.119
Residual	20	12.7520	0.6376		
Total	24	18.1056			

Variate: shell weight					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	2.2656	0.5664	2.17	0.109
Residual	20	5.2160	0.2608		
Total	24	7.4816			

AP. 3 ANOVA Tables for serum biochemistry and haematology.

Variate: ABL					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	103.01	25.75	1.05	0.408
Residual	20	491.42	24.57		
Total	24	594.43			

Variate: ALT					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	114.86	28.71	0.95	0.458
Residual	20	606.48	30.32		
Total	24	721.34			

Variate: AP					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	45347.0	11337.0	2.91	0.048
Residual	20	77990.0	3900.0		
Total	24	123337.0			

Variate: AST					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	1309.0	327.0	0.24	0.912
Residual	20	27249.0	1362.0		
Total	24	28558.0			

Variate: Globulin					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	239.03	59.76	0.62	0.656
Residual	20	1938.42	96.92		
Total	24	2177.45			

Variate: TP					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	661.4	165.4	0.82	0.526
Residual	20	4020.6	201.0		
Total	24	4682.1			

Variate: HCT					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	26.92	6.73	0.43	0.784
Residual	20	312.02	15.60		
Total	24	338.95			

Variate: Hb					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	1.998	0.499	0.47	0.758
Residual	20	21.320	1.066		
Total	24	23.318			

Variate: MCH					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	3.754	0.939	0.48	0.749
Residual	20	38.936	1.947		
Total	24	42.690			

Variate: MCHC					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	2.9400	0.7350	0.97	0.444
Residual	20	15.1000	0.7550		
Total	24	18.0400			

Variate: MCV					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	28.430	7.107	0.94	0.463
Residual	20	151.804	7.590		
Total	24	180.234			

Variate: MPV					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	4.6056	1.1514	3.30	0.031
Residual	20	6.9760	0.3488		
Total	24	11.5816			

Variate: RBC					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	0.1180	0.0295	0.27	0.895
Residual	20	2.1996	0.1100		
Total	24	2.3177			

Variate: WBC					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	18.234	4.558	0.57	0.686
Residual	20	159.427	7.971		
Total	24	177.661			

AP. 4 ANOVA Tables for production performance

Variate: Egg Weight					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	2.788	0.697	0.20	0.935
Residual	20	69.749	3.487		
Total	24	72.537			

Variate: Egg mass					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	98.22	24.56	1.78	0.172
Residual	20	275.32	13.77		
Total	24	373.54			

Variate: Feed intake					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	92.65	23.16	1.13	0.369
Residual	20	408.76	20.44		
Total	24	501.40			

Variate: HDP					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	250.04	62.51	2.23	0.102
Residual	20	5559.73	27.99		
Total	24	809.77			

Variate: Feed to egg mass					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	0.31893	0.07973	1.41	0.268
Residual	20	1.13271	0.05664		
Total	24	1.45164			

Variate: Mortality					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	2.5600	0.6400	1.60	0.213
Residual	20	8.0000	0.4000		
Total	24	10.5600			

Variate: Feed to egg mass					
Source of variation	df	Ss	Ms	v.r	F pr
Treatment	4	0.31893	0.07973	1.41	0.268
Residual	20	1.13271	0.05664		
Total	24	1.45164