FERTILITY AND HATCHABILITY OF EGGS FROM BROILER BREEDER HENS FED DIETARY SUPPLEMENT OF VITAMIN E, SHEABUTTER AND PALM KERNEL OIL

By

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Matriculation Number: 165829

A thesis in the Department of Animal Science

Submitted to the Faculty of Agriculture

In partial fulfillment of the requirements for the

Degree of

DOCTOR OF PHILOSOPHY

Of the

Faculty of Agriculture

University of Ibadan

Ibadan, Nigeria

February, 2020

CERTIFICATION

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DEDICATION

This thesis is first of all dedicated to the glory of God Almighty and to the memory of my father, Late Elder G. O. Adeyemi and to my loving mum, Deaconness R.A. Adeyemi for the great support I received from them to become who I am today.

ACKNOWLEDGEMENTS

I am eternally grateful to the Almighty God, for the uncommon grace extended to me to rise up to the challenge of the study for a doctoral degree. May His Name be praised forever. I am eternally grateful to my supervisor and mentor, Dr. O. A. Ogunwole, a rare gem and a true specialist in the field of vitamin-minerals and amino acids metabolism who provided direction for me to achieve my research objectives. Thank you for believing in me sir.

My appreciation also goes to Professor A. E. Salako, Head, Department of Animal Science, Dr O. Odu, the Postgraduate Coordinator, Department of Animal Science. I am very grateful to the lecturers in Agricultural Biochemistry and Nutrition Unit for their support: The late Head of Unit, Professor O.O. Tewe, may his gentle soul continue to rest in peace. I am also grateful to Professors A. D. Ologhobo and E. A. Iyayi, Drs O. A. Abu, Adebisi, F. Agboola, B. R. O. Omidiwura, Oluwafunmilayo Adeleye.

My appreciation goes to the lecturers in the Department of Animal Science namely: Professors D. O. Adejumo, O. J. Babayemi, A. B. Omojola M. K. Adewumi, T. O. Ososanya, Drs O. O. Olusola, G. O. Adeyemo, E. O. Ewuola, O. A. Olorunnisomo, O. A. Adebiyi, O. A. Sokunbi, H. O. Osayiwu, and O. Alaba for their constructive criticism of the work during seminars to make the research better.

I also thank all the Non-Academic staff and the Technologists of the Department of Animal Science most especially Mr Adelani and Mr Taofeek and other members of their team for their unflinching support throughout my experiment at the laboratory and the entire programme. I am also grateful to all my doctoral colleagues too numerous to mention. I am particularly grateful to my seniors under the supervision of Dr Ogunwole; Drs B.S. Adedeji, A.O Mosuro, F.O Jemiseye and those still under his supervision; Titilope Abokede, Sabur Olademeji, Sherifat Olufeko, Ireti Oludoyin and and the masters students; Asebiode, Aluko, Faith Adenigba as well as the undergraduates. Thank you for your support and may you not stand alone in the battle of life.

I want to thank the entire our lady seat of wisdom, University of Ibadan for providing us with a suitable reading room which really helped in the timely completion of the

thesis. I also want to thank Pastor Alawale and Elder Adunola for their interest towards my timely completion of the program.

My appreciation goes to my family members starting from my late Dad, Elder G. O. Adeyemi who was there for me all the time until few months to my final defense and my mum, Deaconess R. A. Adeyemi who challenged me relentlessly to push on even when I was about to give up. My siblings and their spouses: Engineer Kolawole Adeyemi and wife; Aunty Kemi, Pastor Gbola Oyebode and my elder sister; Funmi, Dr Sola Adeyemi and wife; Jumoke and Barrister Opeyemi Adeyemi. I thank you all for the moral, financial and spiritual support towards the attainment of this enviable feat.

I will also want to thank all the grand children of Adeyemi dynasty; Momore, Moyinoluwa, Moyosore, Taiwo, Kehinde, Mololuwa, Esther and Emmanuel.

Ayodeji Afolabi Adeyemi
NOVEMBER, 2019

ABSTRACT

Broiler breeder stocks are characterised by low egg fertility and hatchability. These limitations could be mitigated by dietary supplement of Vitamin E (VE). Synthetic supplemental VE is often employed in breeder hen production, however, vegetable fat and oils are natural sources of VE. The use of natural sources of VE to reduce infertility and improve hatchability has not been adequately documented. Therefore, effects of dietary supplementation with VE inherent in plant sources on production efficiency and performance of broiler breeder hens were investigated.

Shea Butter (SB), Sesame Seed Oil (SSO) and Palm Kernel Oil (PKO) were analysed for Peroxide Value (PV, meq/kg), Acid Value (AV, mgKOH/g) and VE (µg/mL) using standard procedures. Arbor Acres plus broiler breeder hens (n=180) weighing 3.85±0.49kg, aged 30 weeks were randomly allotted using completely randomised design to diets supplemented with synthetic VE at 0 (T_a), 20 (T_b), 40 (T_c), 60 (T_d), 80 (T_e), 100 IU/kg (T_f) for eight weeks. Egg fertility and hatchability were determined using standard procedures. Another set of Arbor Acres plus broiler breeder hens (n=200) weighing 4.47±0.20 kg, aged 42 weeks were randomly allotted to diets supplemented with 0.0 (T_1), 1.5 (T_2), 3.0 (T_3), 4.5% PKO (T_4), 1.5 (T_5), 3.0 (T_6), 4.5% SB (T_7) and 37.0 IU/kg synthetic VE (T_8) for eight weeks. Hen Day Egg Production-(HDEP), fertility and hatchability were assessed. At week 50, blood (3mL) was sampled and assayed for catalase and Superoxide Dismutase-SoD (µ/mg). Data were analysed using descriptive statistics, polynomial regression and ANOVA at $\alpha_{0.05}$

The PV of 7.4±3.3 in SB was higher than 0.7±0.3 (PKO) and 0.4±0.2 (SSO). The SB had significantly lower AV of 10.7±1.0 than PKO (25.3±2.5) and SSO (17.2±3.2). The VE of 119.2±1.3 in SB was significantly higher than 24.4±1.3 (PKO) and 69.6±2.2 (SSO). Fertility of 96.6+0.8% in T_c was higher than 90.0±2.3% (T_a), 93.8±0.6% (T_b), 93.9±2.3% (T_d), 92.4±1.9% (T_e) and 90.9±2.4% (T_f). Hatchability of 86.4±1.9% in T_f was significantly lower than 93.3±1.8% (T_a), 92.9±2.0% (T_b), 96.9+1.5% (T_c), 93.2±0.9% (T_d) and 91.2±1.7% (T_e). Relationship among synthetic VE inclusion with fertility and hatchability was quadratic (R^2=0.52 and 0.63, respectively). Optimum fertility and hatchability were recorded at 37 IU/kg VE. The HDEP of T_5 (65.4±8.5%), T_6 (70.8±8.5%), T_7 (68.3±8.0%) and T_8 (69.1±5.6%) were similar and significantly higher than T_1 (54.1±5.1%), T_2 (59.4±11.5%), T_3 (59.9±10.3%) and T_4 (52.7±8.5%). Higher fertility was obtained in eggs from chickens in T_6 (95.5±1.1%), T_7 (94.4±1.4%) and T_8 (95.2±1.2%) than T_1 (82.9±2.3%), T_2 (82.4±2.6%), T_3 (87.9±0.8%), T_4 (88.1±2.1%) and T_5 (90.7±1.7%). Hatchability of 85.9±4.1% (T_1) and 85.2±1.5% (T_2) was significantly lower than 89.6±0.8% (T_3), 91.9±0.8% (T_4), 92.9±1.4% (T_5), 95.8±1.1% (T_6), 94.5±0.9% (T_7) and 96.2±0.5% (T_8). Regression of dietary SB on egg fertility and hatchability were optimal at 3.2% (R^2=0.75 and 0.58, respectively). Catalase was significantly lower in T_2 (548.9±52.2) and T_1 (550.7±49.6) while SoD was higher in T_6 (7.2±2.2), T_7 (7.2±2.0) and T_8 (7.2±2.0) than in other treatments.

Dietary supplementation of shea butter at 3.2% level optimally enhanced fertility and hatchability of broiler breeder eggs.

Keywords: Supplemental vitamin, Arbor Acres plus, Broiler breeder chickens, Innate plant *α* tocopherol, Serum enzymes activity

Word count: 490

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CHAPTER ONE

1.0 INTRODUCTION

Fertility and hatchability are major reproductive indices which are affected by genetic and non-genetic influences (Brillard, 2003). Some non-genetic influences affect hatchability one of which is the nutritional requirement of the developing embryo. Inadequately stored nutrients in egg can result in embryonic mortality which causes low hatchability. Broiler breeder diets also impact consequent egg production and embryogenesis. Apart from the genetic component of the hen, maternal nutrition is the next most important contributor to the performance of offspring (Kidd, 2003). Latshaw (1991) concluded that nutrition affects the immuno-competence of chickens especially, trace nutrients such as fat soluble vitamins like Vitamin E (VE) which cannot be synthesized by poultry species hence, the need to have it supplemented in the diet.

Vitamin E has been reported to be an exceptional inhibitor which prevent propagation of free radicals thereby protecting cells and tissues from destruction prompted by free radicals. This can be achieved by donating H^+ from the hydroxy group on the ring structure to the free radical thereby making them unreactive. They are particularly useful in preventing oxidation of poly unsaturated fatty acids (PUFA) present in high concentration in eggs (Mohiti-Asli *et al*., 2008). They are usually at the water-lipid interface in the membrane structure hence their ability to scavenge for free radicals. Free radicals are Reactive Oxygen Species (ROS) or Nitrogen Reactive Species (NRS) which are positioned in the outer trajectory of an unpaired electron. They perform physiological roles which include defending the body against infectious diseases and initiation of mitogenic responses. However, when present in excessive level, they can cause peroxidative damage to the cells (Fransen *et al*., 2012).

Vitamin E absorption from the intestine is reported by Cohn *et al*.,(1992) to be dependent on sufficient pancreatic function, bile secretion and micelle formation. The digestion is similar to those of dietary lipids which are efficient emulsification, proper solubilisation by bile salt to form micelles, uptake by enterocytes and secretion into the circulatory system via the lymphatic pathway. The micelles aggregate the vitamin E molecules, solubilises and transport them through the brush border membrane of the enterocytes through diffusion. The tocopherols are then incorporated into chylomicrons within the enterocytes and released into the intracellular cavity and lymphatic system then successively into the circulatory system where they are transported by high and low densities lipoproteins and red blood cells to the liver. Although, the route of uptake of all tocopherol homologues in the diet are similar, α-tocopherol forms are predominant in the blood and tissues due to the action of the binding protein that preferentially select α-tocopherol over others. The VE is reported to be very essential for fecundity and hatchability of breeder eggs (Narahari *et al.* 2002). A unit increase in the fertility and/or hatchability of total eggs (primary productivity criteria) converts into a great financial value.

Previous study, (Surai *et al*., 2001) ascertained that an additional concentration of VE in the diet of male poultry could elevate the *α*-tocopherol composition of the semen. Surai *et al*., (2001) supplemented rhode island red male chicken diet with 0, 20, 200 and 1000 mg/kg *α*-tocopheryl acetate for 56 days and observed a reduced lipoperoxidative damage in the semen especially in the males supplemented with 200 mg/kg. The reduced damage was attributed to increased VE concentration in the semen. Also, Stuart and Kane (2004), reported an increased litter size at birth when the diets of swines were fortified with additional VE. Vitamin E also resulted in increased survivability of piglets (Allan and Bilkei, 2005). These important attributes may be due to the scavenging tendencies of VE (Sun *et al*., 2009). They play important roles in capturing oxygen and nitrogen atoms that are released during the various reactions taking place in the body. Heritable selection for traits of economic importance reduces the required time to attain the preferred attributes but also increases the tendencies of metabolic conditions,that may be identified at the embryonic stage. Broiler breeders are prone to increased risk of pulmonary arterial hypertension, because the cardiovascular system is unable to deliver the required amount of oxygen to the muscle tissues compared to its energy requirement. To compensate for the oxygen insufficiency, their circulatory system must function optimally compared to their layer

counterpart to release adequate oxygen to the under supplied muscles (Ho *et al*., 2011). The use of antioxidants and anti-oxidative substances in poultry nutrition could limit these adverse effects and enhance production and reproductive performance, but cognisance should be given to the nutritional stability of such feed ingredients.

Dietary oils contain high quantity of essential nutrients which include vitamins and antioxidant compounds. Oils were previously used in the feed of avians as a source of energy, however, they are critical in the absorption of dissolved vitamins and calcium (Leeson and Atteh, 1995). Examples of dietary fat and oils used in poultry diet are palm oil, poultry grease, corn oil, sheabutter, palm kernel oil, soyabean oil, sunflower oil and tallow (Sanz *et al*., 1999). Shea butter is characterised by greater quantities of unsaponifiables relative to other vegetable fats and oil. The amount could range from 0.04 to 0.11g per 100g (Alander, 2004), while other oils and fats ranged from none to 0.02g per 100g (Gunstone, 2000). Maranz *et al*. (2004) discovered that the tocopherol component of shea butter varied widely and could reach up to 0.0805% of the shea butter content and α-tocopherol make up over 65% of the tocopherol found in the shea butter. However, factors such as temperature, post harvest and processing methods, regional variability, subspecific variation all affect the fatty acid and unsaponifiables content of shea butter.

Palm kernel oils are excellent sources of lauric and myristic acids. However, it still remained the choice oil of inclusion in poultry nutrition partly because of its relative availability and cheap price when compared to other oils. Saturated fatty acids especially when combined with gluteinous cereals e.g wheat and barley (with greater concentration of non-starch polysaccharides) increase digesta viscosity and depress nutrient digestibility by impeding diffusion of digestive enzyme and substrate (Choct, 1997). The increased digesta viscosity causes a reduction in gut movement and the degree of flow of emotion droplets, mixed micelles, bile salts and dissolved fat soluble vitamins. Dimitrov *et al.* (1991) also recorded an increment in α-tocopherol absorption in human subjects that consumed high-fat diets. alpha-tocopherol is capable of being transferred to the egg and higher levels of α-tocopherol will enhance egg's antioxidative activities. Nutrient supply for standard embryonic progression and development in the egg originate from maternal diets, absorptive capacity, metabolism and deposition of the nutrient. Although, there are studies conducted on optimum

vitamin nutrition in layers (Zang *et al*., 2011), antioxidative stability in skeletal muscle of broiler fed supplemental α-tocopherol (Gao *et al*., 2010), the fertility and hatchability of Arbor Acres plus broiler breeder when optimum α-tocopherol supplementation from natural and synthetic sources were used have not been adequately documented. This research was intended to investigate the consequences of natural α-tocopherol rich oils and synthetic α-tocopherol on reproductive parameters of broiler breeder hens.

1.1 Objectives

1.1.1 General objective

To improve the production of fast growing Arbor Acres plus broiler chicks under tropical conditions by optimising fertility and hatchability in broiler breeder hens through appropriate dietary supplementation of vitamin E.

1.1.2 Specific objectives

- To characterise the test dietary oils (palm kernel oil, shea butter and sesame seed oil)
- To evaluate the impact of natural and synthetic vitamin E inclusion on fertility and hatchability of eggs from broiler breeder hens
- To evaluate the impact of vitamin E overage addition on blood profile of the hens

1.2 Justification

Fertility and hatchability are the main challenges in commercial broiler production. The fertilising ability of females like their male counterpart are important for the successful hatching of healthy offsprings. In poultry species, parameters such as egg production, egg quality characteristics i.e both internal and external characteristics and egg fertilising and hatching abilities are all important factors which determine the quality of chicks. The percentage of fertile eggs that is transfered for hatching determines the eventual productivity of hens (Khan, 2011). Since the chicken embryonic development are maternal independent after the egg is laid, the developing embryo is reliant on the nutrients deposited in the egg for survival. A chicken egg contain an appreciable quantum of nutrients, including energy, amino acids, fatty acids, dissolved vitamins and minerals, and they may be varied in the eggs by

modifying the hen's nutrient profile. An adequate and timely modification will therefore aid fecundity and hatchability.

Vitamin E is a chain breaking anti oxidant which prevent lipoperoxidative damage of fatty acids especially poly unsaturated fatty acids. Vitamin E being a fat soluble vitamin are obtained in large proportion in fats and oils such as soya oil, sesame seed oil, palm oil, palm kernel oil, sheabutter. However, they also exist in synthetic form as dl- alpha tocopherol acetate and the activities of both natural and synthetic vitamin E are similar.

The indiscriminate use of dietary oils in the supply of energy in poultry is a common practice (Baiao and Lara, 2005). However, consideration should be given to the innate vitamin composition of the various oils. Studies (Maranz and Wiesman, 2003; Akihisa *et al*., 2010) conducted on the tocopherol and total carotene contents of shea butter concluded that shea butter has a good profile of these vitamins. The authors noted that shea butter are made up of mainly triglycerides and a huge proportion of unsaponifiable components, the unsaponifiable content of shea butter ranged from 1.2% to 17.6%. However, Adriaens (1943) found that the ripening of the fruit has an inverse relationship to the quantity of unsaponifiable matter.

The fatty acid profile of palm kernel oil and coconut oil are comparable, however, both palm kernel oil and coconut oil are the major contributor of lauric acid among vegetable oils. Although palm kernel oil are more saturated than palm oil, they do not contain cholesterol or trans fat (Dian and Lida, 2018) hence their use in the poultry industry.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Optimising fertility in Poultry breeding industry

Poultry breeding programmes and facilities in developing countries are mostly established at a small scale level with the hens and cocks used for the breeding of good egg production and fertilising ability (Glatz, 2010). Breeding hen at young age produced less fertile eggs when compared to older hen at peak lay, although fecundity is often poorer in eggs produced by aged breeder hens (Pedroso *et al.,* 2005). The reduced fertility could be explained by the observation of Fasenko *et al.,* (1992), which attributed it to a drop in the capacity of ageing hens to sustain semen in their uterovaginal host glands. It is the breeders' management personnel that determine hatchability and uniformity of hatched chicks. Eggs collection occurs four to six times in large scale operation in order to prevent cracking, and must not be stored for above seven days in the cold room at temperature not exceeding 17°C; and a maximum of 75 percent humidity. Organic matter such as faeces should be cleaned from the shell using abrasive paper (Cobb-Vantress, 2008).

Breeding chicks are discretely separated on the farm and the cockerels are reared in a separate pen from females for a period of five months. However, rearing of birds in tropical environment especially in unindustrialized countries is usually done in open-sided pens. Chicks are known to often scatter the litter which make the litter distribution uneven especially those around the feeding and drinking troughs. An uneven litter distribution around the feeder and drinker will prevent inadequate feeding because of the inability of the chicks to properly reach the feeders and drinkers. Adequate temperature of 32°C is required for poultry buildings prior to chicks arrival

under cold climate. Leeson and Summer (2000) have also emphasized the importance of providing light for 48 hours after the arrival of the chicks.

Cobb-Vantress (2008) and Glatz (2010) noted that beak trimming activity should be practised often to prevent injurious pecking in the flock, and ensure uniform weight for age. Body weight of birds and maintenance requirement during the period of egg production should be considered for feed supply. Lewis and Morris (2006) emphasised the importance of uniformity in the course of breeder development. In developing countries, factors such as poor feed qualities and heat stress limit the potential of breeder chicks for optimum performance when compared with what is obtainable in developed countries. During six to sixteen weeks, meat breeders are on feed rationing to maintain a slim bird. Lightening programme is introduced at 20 weeks to enhance sexual development and to prevent photorefractoriness (phenomenon which gives rise to seasonal breeding) (Lewis, 2010).

However, authors (Leeson and Summer, 2000; Gous *et al*, 2000) observed that daily feeding may affect body weight uniformity as well as the welfare of the chickens because the more timid chickens may miss out of their daily allowance due to aggression from the dominant ones. From three weeks of age, broiler breeders are placed on daily restrictive feeding. Cockrels are usually fed separately from the hens during the laying period to cater for the different necessities of the cockerels and hens. The beginning of lay in breeder hens is affected by changes in day length, as increased day length stimulate sexual maturity.

The body of domestic chickens are often affected by meteorological elements and their effect are dependent on the degree of variation (Ayo *et al.,* 2010). The effect on birds may be positive or detrimental as Bianca (1976) established that low and high environmental temperatures and relative humidity impose various effects on animal well-being, and it's evident on neuroendocrine, cardiorespiratory systems. The concern for meteorological elements recently are as a result of continuous changes that affect internal and external environments of birds (Oladele *et al*., 2003). Bannor and Ogunsan (1987) observed that the effect of meteorological variables on poultry birds is more pronounced in tropical environment thereby resulting in heat stress. However, in temperate regions animals are intensively reared under automated microclimate conditions, thereby reducing stressful conditions. In Nigeria, avian species are

continuously under the influence of heat stress because they are reared extensively or intensively and they do not have sweat glands which can help to cool the body temperature in a non-controlled micro climate. Even modification to alleviate the consequences of heat build up are usually insufficient.

Ayo *et al*. (2010) attributed heavy economic losses to heat stress, and it's evident in reduced growth rate, reduction in daily egg production, higher cost of production, increased mortality and failure in reproduction. Growth rate and egg production are reduced in heat-stressed broiler breeders because of the reduction in voluntary feed intake; an indication of high thermal loud suppressing enterocyte proliferation and growth. The authors demonstrated that heat-stressed broilers had significantly lower body vitamins A and E (Sahin *et al*., 2001). The triiodothyronine and thyroxine concentration in the plasma were significantly affected in heat-stressed chicken with growth performance reported to be hampered (Sahin *et al*., 2001).

Mearns (1997) noted that ambient temperature has a great influence in broiler reproductive ability through manipulation of feed intake. Ayo *et al*. (2010) observed a 20% decrease in consumed feed when laying birds were stressed during high temperature dry season and resulted in substantial reduction in hen-day production. Abd-Ella (1995) observed a remarkable decrease in hen day egg production due to reduced feed intake during harsh weather condition. There is a decline feed consumption of birds during heat stress in an attempt to physiologically reduce the heat increment generated from metabolism of feeds. De-Fariara *et al.* (2001) reported poor internal and external properties of eggs when layers are exposed to stress. Dantzer and Kelly (1989) observed that immunity is subdued by the activation of Cytokine IL-1 by stressor either physical or emotional which then lead to fever and resultant reduction in feed consumed. Cytokine IL-l may also facilitate behavioural responses due to heat stress, resulting in heat-induced infertility in birds, through pulsating gonadotropin-releasing hormone generator frequency disturbance and impairment of Follicle Stimulating Hormone and luteinising hormones secretion in layers.

McDaniel *et al*., (1996) reported the effect of heat stress on sperm cell production in breeder cocks. Moderately high temperature improved testicular growth, increased semen concentration and volume at early phase but later suppressed reproductive capacity through decreased seminiferous epithelial cell differentiation. Prevention of

the exchange of calcium and potassium ion can significantly reduce spermatogenesis whereas, non-inhibition during spermatozoa development may assist differentiation of seminiferous epithelium (Schreiber *et al.,* 1998). McDaniel *et al*. (1996) established that multiple effects result from heat stress on testicular functions by preventing intracellular ion exchange. Roosters are greatly affected by environmental stress as it causes infertility in all breeds of chickens. Banks *et al.* (2005) observed that heat build up also affect the productive performance of other species of animals. In mammals, high level of free radicals is positively interrelated to decline spermatozoa movement (Armstrong *et al*., 1999). McDaniel *et al.,* (1996) observed that broiler roosters are more sensitive to by temperature-induced infertility compared to females; fertility is observed to decline by 42% while the egg penetration is also dropped at 32^{o}c environmental temperature compared to those kept at thermos-neutral zone.

Differential tissue growth and skeletal development in fertile egg during incubation is attributable to over-heating of the eggs. According to Ande and Wilson (1981), electric power failure predominant in Nigeria also disrupt the proper functioning of incubator fan and turning systems, resulting in embryonic heat stress.

2.1.1. Achieving Efficient Broiler Breeding Chicken

Development in chicken breeds through selection to meet the commercial objectives of the market has made a lot of progress in recent times, the success recorded could be ascribed to advancement in quantitative genetics which has made selection effective (Tallentire *et al.,* 2016). Broiler breeder pay attention to rapid growth rate of the broiler strain, however recently more attention are paid to the breast yield, lower mortality and better feed efficiency. The growth recorded between the 1950's and 2005 have been reported to be over 400% compared to similar birds raised under the same conditions.

The recent progress in broiler breeder production came with challenge which included increase feed consumption within short time. The high feed consumption has also resulted in increased greenhouse gases release by feed manufacturing plants in effort to meet the increasing demand as well as reduce nutrient in poultry feaces used as poultry manure due to efficient usage of feed nutrient (Tallentire *et al.,* 2016). Nutrient in feed determine the rate of consumption especially, energy, protein and fat, this is an indication that increase in feed efficiency will require increased efficiency in the

energy contributing nutrients required to meet the target weights of the birds as fast growing broiler need to convert more of the feed energy for development of muscle and less for metabolic process (Emmans, 1997). The efficiency of feed consumed by birds is related to various biological functions in the body of birds such as behaviour, digestibility, protein and fat metabolism, age and other related metabolic activities. Formulation of feed is critical in determining its efficiency, modern broiler require energy dense, higher requirement of amino acids and a well-balanced diets compared to broiler raised 30 years back (Tallentire *et al.,* 2016). Feed intake of birds is also influenced through stimulations with lighting periods to achieve an increased growth rate. Housing condition, spillage of feed, feed forms, behaviour of birds, development of digestive organs have all been attributed to efficiency of feed in broiler chicken (Tallentire *et al.,* 2016).

Layers and broiler originating from similar ancestors does not translate to similar digestibility. Pishnamazi *et al.* (2005) compared pullet (Laying birds strain) with broilers of the same age and observed significant difference in their feed metabolism with pullet recording a better energy from the feed offered. The observed difference was attributed to increased nutrient pressure exert on the digestive function of broilers to meet the growth rate. The improvement in rapid growth in broiler chicken have also resulted in improved dressing carcass percentage as it imply that higher rate of growth and faster rate of maturation resulted in a commensurate reduction in organs such as the digestive tract; it is expected as the generation and maintenance of digestive system require higher level of energy, reducing the size is believe to reduce the demand for energy and improve the total energy efficiency (Haventein *et al.,* 2003)

Ravindran *et al.* (1999) observed that variances in the utilisation of nutrient among breeds of chicken could be due to configuration of the gastrointestinal region as it relates to their absorptive capacity, gastrointestinal enzyme and time required for complete digestion. Digestion in poultry is more of enzymatic because of their small colon and absence of bacteria that could help with degradation. Nir *et al.* (1993) reported that enzyme secretion hinder genetic improvements in broilers. There is a direct relationship between chicken weight and intestinal trypsin and amylase absorption (Dunnington and Siegel, 1995). Bedford, (1996) reported that differences in intestinal capacity and absorptive region occured between broiler strains.

The body composition of chicken have been influenced by the increased rate of growth, chicken meet their slaughter faster relative to age of maturity and tend to have less fat compared to weight at maturity (Katanbaf *et al.* 1988). Schmidt *et al.* (2009) noted that the chest meat increase two fold faster than the overall body growth, the muscle of the breast of old broiler strain peaked was at 9% on day 14 compared to 14% recorded for modern broiler which increased significantly to 18% at day 35. Fleming *et al.* (2007) reported that modern broiler chicken breast meat after slaughtering has almost doubled compared to those obtainable in the 1970's while the wing muscle and heart has reduced in modern broiler strain compared to broiler raised in the 1970's. Havensteins *et al.* (2003) observed that due to genetic difference in broiler chicken raised in between 1950s and 2001, there is reduction in the wings size to 2.2 and 2.0% at day 43 and day 47 comparatively with the corresponding body weight at that age. The heart weight of the old broiler contributed 0.57 and 0.50% to the body weight at day 43 and 57, while the newer broiler strain recorded 0.50 and 0.44% respectively at day 43 and 57 respectively

2.1.2. Artificial Insemination Strategies in Poultry Breeding

Artificial Insemination (AI) like other Assisted Reproductive Technologies (ART) is an important tool in poultry which involve spermatozoa collection from the rooster and its introduction into the hen with the aim of fertilization of the eggs. It is done in livestock breeding programmes to obtain and promote the propagation of desirable qualities of one male to many progenies (Bakst and Long, 2010). Donoghue and Wishart (2000) noted that artificial insemination is efficient in improving reproductive efficiency of poultry birds. Artificial insemination impact has also been the foundation for other biotechnologies such as cloning and sexing of sperm, it is also a tool for improving reproductive efficiencies in poultry (Dhama *et al.,* 2014). Gordon, (2005) posited that artificial insemination also helps in the efficient use of semen as it requires less than 0.1ml to inseminate a hen. It is established that artificial insemination resulted in improved fertility than natural mating and also resulted in genetic improvement and increased selection differential. Am-in *et al*., 2009 observed a higher litter size when sows were artificially inseminated compared to natural mating. Artificial Insemination has contributed significantly to propagation of domestic birds and other pets. It is also considered cost-effective in broiler breeder management as

fertility decline with selection of male for growth (Dhama *et al.,* 2014). It has also been employed in the preservation of species which are becoming endangered and rare like peregrine falcons. Artificial insemination can also be used to solve some of the behavioural challenges related to mating (Froman *et al*., 2011). In certain birds, like turkeys and Cranes, semen collection and artificial insemination are used frequently, however, in larger Psittacines, anecdotal semen collection method has ben reported (Lierz, 2008). Quinn and Burrows (1936) introduced the most commonly used method of artificial insemination which involve the application of pressure on the abdomen to bring out the vagina orifice. Semen is then deposited in the orifice by means of syringes, and the profundity of insemination subject to bird's species and vagina length.

Artificial insemination advantages over natural mating in poultry are not restricted to multiple growths in mating ratio especially when appropriate semen extender are used. There is the use of older males of outstanding performance for genetic improvement. Male birds with good features of interest to the breeder but which have mating challenge due to leg problem can still be effectively used while poor fertility issues relating to territoriality and fighting for female by cock will be reduced. Challenges poor fertility when a cock are isolated with several female hens in cages are address with artificial insemination as semen of different cock could be pooled together before insemination which increase the chance of fertility and cock with poor semen quality are compensated for by those of good semen quality (Surai and Wishart, 1996).

Transmission of contagious or infectious disease is reduced with artificial insemination though they are prone to those that could be transmitted through the semen (Chaudbury, 1996). Transportation of birds over a long-distance induce stress and it is difficult when compared with semen transportation which is easier and could be done on a large scale. Poor nutrition may predispose birds to diseases, fatigue and reduced performance of the birds selected for breeding.

Stipkovits and Kempf (1996) stated that personnel who are involved in the breeding programmes require proper knowledge on the semen collection methods which prevent the presence of impurity and microbes. The addition of anti-microbials at optimum concentrations is crucial for obtaining an effective artificial insemination programme

in poultry. The choice of antibiotics is central to elimination of sexually transmitted disease of bacterial origin in poultry.

Conan *et al*. (2012) established that strict bio-security principles need to be observed in order to get rid of pathogens which can compromise the environment during the process of artificial insemination. For any effective artificial insemination to be carried out, all equipment must be kept clean because semen are nutrient rich substances hence a fertile ground for bacteria growth. Dhama *et al*. (2007) reported that key principles of bio-security include isolation, traffic control, sanitation, which all explained the reason for building pen houses in secluded areas, disinfection of materials, and equipment among others. When there is risk of breakdown of bio-security norms such as introduction of new batch of bird which pose health risk to the flock, management of such challenges becomes a priority as high level of human and environmental management would reduce infectious diseases greatly.

2.2 Intensive management system and effect on welfare and broiler chicken production

Production performance of exotic birds must be scrutinized frequently to set lay down rules for policy makers, as inadequate record makes it challenging to evaluate the contributions of the previous attempts and strategies for future improvement. Substantial evidence have indicated that intensively managed exotic strains of chickens performed better (Yami and Desie, 1997).

In Ethiopia, in an effort to improve the indigenous chickens, exotic chickens were distributed, principally Rhode Island Red (RIR) improved cock was mated with the indigenous chickens (Sebho, 2016) According to Permin (2008), improvement of local chickens usually fails most selected exotic or improved breed cannot adapt to changes in hot climate, low feeding and extensive management. Alganesh *et al.* (2003) compared local and imported hens in terms of their frequency of lay. The authors observed that local hens are only capable of producing 30-60 eggs per year per hen when compared to the whopping 260 obtained from exotic hens. This is attributable to the genetic limitations together with the extensive management system that is often practised in Ethiopia.

Abraham and Yayneshet (2010) finding observed that Fayoumi chicken in Oromia Agricultural Research Institute produced maximum of 156 eggs per hen per year which was lower than 176 eggs recorded by White Leghorn and 185 eggs for Rhode Island Red hen. Aberra *et al*. (2005) reported that cross of local and exotic breed of chicken performed better than local and exotic parents under a similar management system.

However, Abraham and Yayneshet (2010) observed 68% mortality in chicks and pullets and about 48.5% in White Leghorn. Moreover, Mazengia *et al.* (2012) observed higher fatalities of non-indigenous chickens at stumpy altitude regions compared to high altitude and mid- altitude districts. Mortality rate of exotic chicken was 45% (Mazengia *et al*., 2012), the author also attributed the higher mortality to low environmental temperature and high environmental temperature which is outside their thermoneutral zone. However, parent stocks are prone to higher rate of mortality in rainy season than dry season.

There is a rise in consumption of poultry products and this has led to poultry-related developmental interventions. Tamir *et al.* (2015) noted exotic breed feeds, vaccines and medications are important input in ensuring increased production of poultry products. Chickens are veritable tools for conversion of plant based nutrients into animal proteins including meat and eggs which are important consumables in human diets. The need for protein source of nutrient is geometrically increasing with the increasing economic income and population growth with resultant reaction on chicken production. According to FAO (2005), with an annual human population growth of 2.4% and Ethiopians are expected to increase in population by 71.9 million from the current population of 77.4 million by 2040. Thus, animal production need to grow at similar rate to meet the expected demands. Ashenafi (2000) stated that reliance on local poultry bird may be difficult to meet the growing demand for poultry product and will require introduction of exotic breed which are fast-growing with great hen day production. Also, intensive management need to be employed in an effort to make meat surplus.

The present poultry production growth in demand and supply makes it necessary for further expansion of the sector. Under poultry production, prevailing diseases, predators, poor feeding and lack of water were reported as the major constraint (Getu and Birhan, 2014). The quality feed in Ethiopia is largely dependent on proper mixing,

availability of vitamin-mineral premix and laboratories facility to ease formulation and testing of quality of feed. Raw material prices, proximity of feed mill plants and efforts to balance the nutrients requirement of the birds while considering the least cost have all contributed the quality of feed as pressure is on the nutritionist to produce good feed and cheap feed.

Achoja *et al.* (2006) identified the feed price per bag and poor road network as major contributors to poor sales for different classes of poultry, stating that bad roads increases the cost of transportation and subsequently significant revenue reduction. Demeke (2004) also reported that proximity of feed mills to source of input and customers as well as unavailability of storage or large volume deliveries have contributed to high cost of feed and challenge in intensive management.

In broiler breeder management, welfare challenges relating to starvation, aggressiveness, frustration are prominent, especially at the rearing phase to ameliorate the health and reproductive challenges attributed to *ad libitum* feeding but a foundation of welfare problem. The growing welfare concerns and growing ban on chicken mutilations have resulted in a search for alternatives management solutions. Environental enrichment has been suggested as tool that can be used to reduce the welfare challenges, noting that it accommodate larger behavioural pattern (Van de Weerd and Day, 2009). Environmental enhancement entails improvement of the surroundings which animals are intensively-housed, for behavioural enhancement and improvement in biological functions, with respect to practical and economic advantage.

The purpose of environmental enrichment is to encourage normal sexual and proper feeding behaviour, however, elevated plane for resting, cover panels among others could be a great source of enrichment, though, there is still the need for study for development of more sources of enrichment and responses of broiler breeders as it relates to, economics, production system, phenotypic and genotypic characteristics. Feed restriction is a tool in management of broiler to prevent health and production challenges relating to *ad libitum* feeding of the birds, though feed restriction is aimed at addressing these challenges, it is a source of welfare problem as welfare challenges have been observed in broiler breeders raised on dip litter and restricted feed without any enrichment. (Bessei, 2014).

Organic production has been highlighted a way of on reducing welfare problems as it had a richer stimuli, however, Steenfeldt *et al*. (2014) opine that genotype of birds could influence different responses while Jones *et al*. (2004) do not see the significant effect of genotype, and sex on responses of birds to feed restriction. Competition for feed among rooster and hens has contributed to aggression which is considered a challenge welfare problem which is pronounced during production, in breeder hens, sexual behavioural expression are different from those of commercial layer hens and jungle fowl (De Jong *et al*., 2009). Millman *et al.,* (2000) study found out that male of broiler breeder hens are more aggressive compared to layer breeder, attributing it to genetic factors since they are of different strain.

Leone and Estevez (2008) observed that in broiler breeders hens, they tend to be attracted to raised slats while the male tends to be raised on the area, the behaviour tend to decrease the chance of mating and when it occurs there tend to be competition for the female which induce stress and results to peck and damages to the plumage and feathers of the female. Preventive methods such as detoeing, despuring, debeaking are usually used, however, these methods are also considered as source welfare challenge. The kind of enrichment should be dependent on the species, behaviour, environment, ability of the birds to handle challenge and biological relevance (Van de Weerd and Day, 2009). This is because environmental improvement require practicability, achievability and should not impose unnecessary challenge to the birds.

Gunnarsson *et al*., (2000) suggested that resting places which are elevated can be used by broiler breeder any time of the year, however, Gebhardt-Henrich and Oester (2014) examination of resting place among two breeds of broiler breeder birds namely Ross (fast-growing breed) and JA (slow-growing birds) and reported that at 20 weeks of age JA birds use elevated plane more often than the Ross birds which had 91% for JA and 80% for Ross, they also noticed that usage is age related for JA birds while those of Ross reduced to about 50% at aged 53 weeks, the low usage by Ross with age could be as a result of higher weight with age. Gebhardt-Henrich and Oester (2014) also observed similar response in broiler breeder of Ross strain when provided with branches along with elevated plane, the elevated plane was used while less than 1% of the birds used the branches, the low usage of the branches could be due to lower plane of the branches than the elevated plane.

Gebhardt-Henrich *et al*. (2016) also identified an interaction between elevated plane and aviary tiers in broiler breeders from Ross 308 and Sasso. 8 perches and four tiers were used as well as an elevated plane, it was observed that the birds tends to elevated perches than raised structures within the pens used for the study and it was shown that the birds preferred the higher perches to the lower ones and production was not affected by the interactive effects. Keel fracture was observed more in Sasso birds than Ross birds recording 39% and 15% respectively from bird who access perches more frequently, however overall 26-32% of the birds had keel fracture. It is therefore important for the elevated places for enrichment to be able to prevent keel damage and prevent negative effect on production indices of interest. Wrapped shaving in plastic bags and plastics string has also been used as a way to stimulate exploratory pecking and foraging (Hocking *et al*., 2005). King, (2001) reported that when Ross birds in dip litters are provided with bale wood shavings as enrichment, a 40% significant reduction in aggressive head pecks was observed in the late rearing phase.

Hocking *et al.* (2005) examined effect of slated and wood-shaving in Hubbard breeder age 8-weeks under two treatment and observed that at the 4th week of age, hens on wood shaving forage more and pecked less, while aggression and pecking of the wall and feeder was higher in birds on slated floor compared to wood shavings floor, plumage damage was also higher in birds on of slated floor. In investigating the consequences of feed sprinkling on bedding materials by breeder pullets (Hybro G), De Jong *et al*. (2005) observed that it excites foraging behaviour. The authors noted further that stereotypic pecks on the cage were reduced, though plasma concentration of corticosterone and glucose was influenced when feed was scattered on the litter or feeding through.

Van Emous and De Jong (2013) reported that in Netherland, commercial housing system which is now in use allow the female broiler breeder hens to be raised separately from the male for 5 hours and separate access to feeder and drinker. Better fertility was recorded when the method was employed as well as improved sexual behaviour and plumage.

2.3 Broiler breeder hen: physiology and nutrition

There is increment in poultry production in recent years, Hafez and Hauck (2005) reported that it has increased 3 times more in the century. The increased production

could be attributed to the work of genetics and nutritionist. The layer birds production has increased with higher hen day egg production and 320 eggs obtained in 52 weeks while in broiler rapid rate of growth have been observed with broiler breeders recording increase in weight up 50 to 60 folds from day old to marketable weight, also embryonic development could be observed in first 48 hour and after hatch out (Druyan, 2010; Ho *et al*., 2011).

The development of fast-growing and producing breed has consequently resulted into high occurrence of metabolic challenges and are something discovered at embryonic stage, the observed metabolic disorder could be attributed to the metabolic demands needed for meet the demand of breeder and genetics and often times result to bone mineralization challenges, failed internal organs. (Hafez and Hauck, 2005) also reported that in broiler birds the demand for muscle mass has resulted in reduced cardiopulmonary capacity and could not withstand high physical force compared to layers birds. Broiler breeders are also more predisposed to arteries challenges as they require high energy diets to meed the muscle demand required of them.

The muscle of fast-growing broiler breeder require oxygen in adequate quantity to meet the energy demand, to meet these demand and address challenges relating to muscle hypoxemia the circulatory system need to provide enough oxygen to perform at optimum capacity and if not enough could lead to heart failure (Ho *et al*., 2011). The endothelin has vasoconstrictive effect which predisposed broiler breeder cardiovascular system to challenges. Genetic improvement in broiler breeders have also resulted in decline in reproductive ability, percentage of egg produced, fecundity and chicks produced per fertile eggs which are caused by skeletal deformation and high body fat.

In layer birds, due to high egg production, they are more prone to fatty liver disease and bone disease though layer hen immune system are less compromised compared to broiler birds.

Chickens at embryonic stage rely mainly on the yolk as their source of nutrients supply (Ho *et al*., 2011). The yolk contains several nutrients, hormone and antibodies that are required by the embryo and it determines the rate of egg development and growth (Ho *et al*., 2011). Rombough (2011) reported that 80% of yolk energy is channelled

towards growth and only 5 % is released as metabolic waste while the remaining 15% is channel to other metabolic processes.

An upset to the yolk will affect the rate of development of bird's embryo, the larger egg yolk mass shows a direct relationship to the embryo mass indicating that yolk mass could be used as tools for predicting mass of embryo (Ho *et al.*, 2011). Embryogenesis in broiler breeder is different from layer breeders as at the late stage as the development of embryo is greater in broiler breed (Sato *et al*., 2007). At day 14 of embryogenesis, significant difference is obtained in the embryonic mass with broiler having higher mass while at day 16 and 19 development was slower and body mass was lower, though at day 20 of embryonic stage, the developing mass is determined by the egg weight rather than birds type. (Sato *et al*., 2006).

Ohta *et al*. (2004) established a positive interaction with respect to the yolk and final weight of broiler birds at 56 days, he observed that a gram advantage of egg weight will result in 10g advantage after 56 days, the difference was attributed to uptake of nutrients from the yolk. Sato *et al*., (2006) observed that yolk sac are readily more absorbed in broiler embryo than layers and broiler had more yolk sac, it was also reported that 3g difference in yolk mass as significant till day 14.

Immediately after hatch, broiler breeders and layers chick depend on yolk sac contents and absorption challenge limits their growth potential and may increase the frequency of unabsorbed yolk in broilers compared to their laying counterpart (Buhr *et al*., 2006).

The nutrients in egg are transferred and used for embryonic development but the nutritional requirement of the chick embryo was not established as egg nutritional composition are affected by several factors such as nutrition of the hen, metabolism of vitamin D, storage days of the egg, calcium allowances and level of vitamin-mineral supplementation (Puthpongsiriporn *et al.,* 2001). Egg from broiler starts to hatch at day 20 while layer hatch 24 hours after, at 504 hours of incubation, broiler birds would have experienced 100% hatch while layers is still hatching (Druyan, 2010). Ohta *et al*. (2004) and Sato *et al*. (2006) have also verified lighter chick weight in layer to broiler chicks and were probably due to additional days which has contributed to embryonic delay in layers. It was also observed that early embryonic mortality was higher after 3 days in broiler breeder compared to layers which recorded 16.4% and to 11.9% respectively, the observed difference was attributed to chromosomal aberration. The

phenotypic difference observed in birds at pre and postnatal period could be as a result of thyroid and testosterone hormone transferred from hen to the egg yolk.

Thyroid hormones have been implicated for tissue development in chickens and the concentration was observed to be low in the yolk of smaller chicks. McNabb and Wilson (1997) reported that during embryogenesis, 350mg of yolk is absorbed (27mg/d) while from day 13 to 15; 230 mg (115 mg/d) while at the last 2 days of the embryogenesis the rate of yolk absorption was increased to about 1g/d, the yolk sac not yet absorbed will be absorbed post-hatch as the yolk sac is a source of thyroid hormone. Broiler eggs triiodothyronine (T3) concentration is reported to be two times higher in layer egg yolk to broiler, plasma T3 is also higher in layer chicks than broiler during embryogenesis though 10-day after hatching, plasma T3 decline in meat-type but rises in egg-type chickens (Ho *et al*., 2011).

The thyroxine (T4) hormone, however, increase in both hens gradually during embryogenesis, however post-hatch T4 increase in broilers and reduce in layers, the observed difference is inversely related to T3 level during embryogenesis (Sigui *et al*., 1999). Druyan (2010) submitted that lower concentration observed in layer birds could be attributed to different metabolic and oxygen demands with a resultant difference in growth of the chickens.

The neuroendocrine system plays an important regulatory role in animal growth especially hypothalamic-pituitary-somatotropic axis. Growth hormone was observed to have no negative consequences on chicks growth. Two hormones, namely somatoliberin/thyrotropin-releasing hormone (TRH) and growth hormone inhibiting hormones (GHIH) are responsible for the regulation of growth hormone of which inhibitory function is done by somatostatin. The expression of mRNA of hypothalamic somatostatin, plasma GH and pituitary GH are lower in broiler hens, though low quantity of GH receptor mRNA is observed in liver of laying hens (Zhao *et al*., 2004). Genetic factor appearance of growth hormones in breeder is greater in laying hens at the 18^{th} day of embryonic development and has a direct relationship with day 5 of age and inversely related to what was obtained at day 10. There is strong positive relationship between GH gene in layer hens relative to broiler breeders, however, it was negatively related to rate of growth post-hatch (Ruqian *et al*., 2001).

Sato *et al*. (2006) noted that discrepances in the growth rate of breeder hens could be attributable to differences in the metabolism of lipids. Egg lipids content is an important energy contributor to the growth of the embryo and accounts for 90% of energy used for development through oxidation of the fatty acids. At embryonic stage, the main lipid source are cholesterol ester while post-hatch, it is replaced by triglycerides in the liver. Though the liver content of triglycerides increased during embryogenesis, it is higher in broiler birds than layers but similar on day 14, but progressively becomes higher as the birds hatched (Druyan, 2010). The observed higher triglycerides in broiler could be ascribed to higher triglyceride uptake in broiler from the yolk. Two weeks post-hatch triglycerides are the major lipid sources obtained in the liver with broiler attaining substantial level of liver triglycerides and absolute liver weight compared to layers but not relative liver weight (Druyan, 2010).

Embryogenesis stage of broiler had concentration of D-3-hydroxybutyrate triglycerides and glycerol higher in layers than broiler, which is an indication of higher usage of lipids by broiler than layers. The absorption fatty acids require carbohydrates, carbohydrate content of the egg is less than 1% and therefore there is need for sources of carbohydrate from other non-carbohydrate sources such as amino acid and glycerol. The usage of glycerol is more pronounce in broiler embryo than layers (Sato *et al.*, 2006).

Heat production during chick embryonic development have been shown to be different with broiler heat production recorded to be lower than layers which decreases gradually with time and a respiratory quotient of 0.7. Higher value of heat production was obtained in broiler embryo compared to layers at day 12 and it decreases until hatching, though similar on day 16 to 18. The lower chick body temperature reported in layer chicks to broiler chicks could be as a result of a sophisticated endothermic response in layer chicks (Everaert *et al.,* 2011).

Metabolizable energy efficiency is critical to the determination of heat energy produced, the basal heat generation is minimal in meat-type chicks than egg-type rom day-old till 500g body weight is achieved, this is an indication that protein turnover in broiler is slower compared to layers. In fed state, protein synthesized more in layer hens than broiler, however, when in fasted state there is no obvious difference (Muramatsu., 1990). Hassanpour *et al*. (2010) reported that maximum utilization of

nutrients from feed is attained at around 3 weeks, which indicates it is the age at which oxygen supply and that is required to meet the metabolizable feed are met as broiler breeder requires larger part of more metabolizable energy for growth than broiler. The first 7 days post-hatch, broilers birds have a lower requirement for resting metabolic rate despite the rapid rate of growth which could be 6 times higher during this period, though this difference between level out at the with time even as broiler grow twice more and higher metabolic rate.

Druyan (2010) reported that at the embryo stage, the rate of consumption of oxygen is higher in layers than in broilers. The lower oxygen intake meant lower rate of fat oxidation and vice versa. Everaert *et al*. (2011) observed that during embryogenesis, layers show a slower development than broilers and this is evident in thinner air cells and carbondioxide concentration in blood, though at day 12-18 similar adaptive method is employed by the two embryo. The lower consumption of oxygen during the development phase of the embryo could have contributed to lower values of embryo haemoglobulin and haemocrit recorded for those of layers (Druyan, 2010).

Janicki *et al*. (2003) reported slower development of embryo in layers when measuring erythropoiesis, though Druyan (2010) reported lower oxygen consumption, layer embryo had higher heartbeat rate.

Ho *et al.* (2011) observed that when embryo from broiler are developed on layers culture medium, it had higher heartbeat rate relative to embryo from layers on broiler culture medium. A lot of progress has been made by breeding company in the development of broiler birds with good feed conversion ratio, rapid growth, improved breast meat, better carcass yield as well as production of good numbers of hatchable egg. Fancher (2014) compared broiler from modern lines to those not selected since the 1950s and submitted that the modern line are much more improve and suitable to provide the meat required. The progress made is an indication that the modern broiler has the capacity to aggregate protein and develop body weight at a fast rate even with low intake of the nutrient. Production of hatching eggs requires proper feeding program, and husbandary, especially during the rearing and layer period as excess protein intake in breeder hen, will result in deposition of fat, over-fleshing and big eggs of poor shell quality (De Beer, 2010). De Beer (2010) also noted that inadequate uptake of energy will compromise the immune system, feather ability, hen day egg

production and hatchability. Therefore nutrition program that will address this challenge need to be developed while research continues till a maximum potential in terms of production of meat and eggs are attained.

Lopez and Leeson (1995) studied the consequences of graded level of protein consumption on the productivity in broiler breeder hens, 4 diets were used with protein intake of 16, 14, 12 and 10% protein which corresponds to 26, 23, 19 and 16g/birds per day intake at peak consumption, it was observed that despite the drop in crude protein of the diets, the fertility and egg production were not affected. However, the birds on 10% crude protein had lighter weight while 10 and 12% had reduced egg size compared to birds on other diets resulting in smaller day-old chick size. It is important to consider egg weight as it has implication on chick weight and will have resultant effect on how heavy the birds will be noting that 2g additional egg weight will result into 1.5g more in chick weight and 100-150g additional weight at six weeks and above. Mohiti-Asli *et al*. (2012) also observed that an increment in dietary CP from 14.5% to 17.4% for hens aged 43-55 weeks gave rise to a 12% weight gain while egg size were not affected. Shefey (2002) reported that the use of high protein diet may have consequence especially beyond the age of 40 weeks and could portend a heavier bird resulting in both higher body weight and egg size; he submitted that this will make maximisation of chick quality at the start of production, egg size and hatch out difficult when not checked.

Chick quality is affected by several factors which are not limited to nutrition, physiology of the hen, hatchery and farm management, transportation and brooding efficiency. Flock uniformity, chick quality, photostimulation, stressor and poor feed distribution have all been implicated in poor breeder hen performance.

The hen stage of development at the start of lay is central to the overall success of the quality of the chicks. Hens of younger age produce smaller eggs, small yolk to albumin ratio, smaller chicks and hatch later compared with those from older flocks. (Ulmer-Franco *et al*., 2010). The delayed hatch in younger age's egg could be attributed to the thickness of the eggshell. Spratt and Leeson (1987) concluded that protein-energy ratio has noticeable consequences on chick weight in their investigation on the consequences of protein-energy ration on egg size, which showed that high-density

feed consumed hens produced eggs with increased size and heavier chicks which were significantly higher at day-42 and day 63.

They also reported that there is need for protein and energy balance for big chick size, chick size was reduced when energy of the feed is high while the protein was low, similar observations was reported when high protein and low energy were used. The author found out that the effect were more pronounced in male chicks produced from hens fed higher energy diets (450Kcal) which had improved growth relative to the ones with lower energy diet (325Kcal) while the females were not significantly influenced.

Amiri Andi *et al*., (2006) also reported that diluted breeder diets are also considered a tool especially in Western Europe for increased egg size, early embryonic development and higher live weight of day-old chick. Significant mortality reduction is also observed when broilers are fed diet of lower density.

Enting *et al.,* (2007) investigated the responses of offsprings from 2100 and 210 broiler breeder hens and cock respectively to energy density of feed, four experiment feed were used, diet 1(control) had metabolizable energy of 2600Kcal and 2800Kcal for growing and laying phase respectively, diet 2 had the metabolizable energy reduced by 12 and 11% during the growing and laying phase respectively, diet 3 had the energy reduced by 23 and 2% for growing and laying phase respectively and diet 4 had metabolizable energy reduced by the 12% at the growing phase but the laying phase had similar energy with diet 1 (2800Kcal). The feeds were offered from week 4 to week 60 weeks. It was observed that day-old chick from birds on diet 2 had higher weight to chicks from the control. At 60 week, parent stock breeder birds on diet 2-4 had less mortality compared to control. The authors concluded that rate of growth of hatch chicks, reduction in mortality and immunity could be improved with lower density diets with consideration of the ages and egg weight.

Moraes *et al.* (2014) compared feed containing 13.7% crude protein, metabolizable energy of 2528 Kcal against diet with 15.3% CP, metabolizable energy of 2736 Kcal at growing stage, on chicks from 28 weeks old breeder hen and submitted that chicks from the breeder hens had a better breast yield with increasing energy protein ratio from rearing stage to laying phase. The result confirmed earlier finding that nutrition of parent has noticeable impact on the chicks rate of growth.

Enting *et al*. (2007) observed reduction in water intake and drinking behaviour in broiler breeder offspring when oat hulls was added in the diets and the quality of the litter was also improved. The improvement in the litter quality could be attributed to fibre contribution of the oat hull as fibre is known to increase transit time in birds and thus better absorption of nutrients.

Study on the effect of lysine shows that hen sourced from corn-based distiller grains with solubles in 26 weeks old broiler breeder results to lower body weight and breast yield while the lowest lysine of 600mg mg/lysine/birds/day results to dark meat yield. Ciacciariello and Tyler (2013) also observed that low level of lysine below the requirement of the breeder hen results in higher chicks mortality at three weeks, it was concluded that change in feed to improve egg production has effect on the livability of chicks. Kidd *et al.* (2005) also established a carry over influence of dietary L-carnitine on chicks from breeder hen.

Vitamin and minerals have also been reported for its various benefits on offspring superiority and performance especially when there is supplementation of vitamin or minerals in the diets. The importance of vitamin D_3 on breeder hen hatch chick weight gain was reported by Atencio *et al.* (2005) when they observed increased weight gain with increasing concentration of vitamin $D_{3,}$ it was also observed the problem relating to progeny chicks improved at 30 -37 week but not older than 45-57 weeks in broiler breeders, 2800IU/kg of Vitamin D_3 was however recommended. Vitamin E has also been prominent for its antioxidant role, the relationship of α-tocopherol on fertile egg yolk and chick tissues post-hatch has been reported by Surai *et al.* (1997). The positive effects of its activity on immunity, chick health and performance have also been reported by Aviagen (2013) and 100IU/Kg recommended for optimum performance.

The effect of overage of vitamin B, K and E were also evaluated by (De Beer, 2010) and it was reported that mortality was reduced and body weight was increased at 20% increase in the selected vitamins.

Organic selenium has also been reported to be a potent antioxidant which enhances selenium concentration in egg and tissue of offsprings (Couloigner *et al*. 2015). Pappas *et al.* (2006) also observed than when chicks were fed 0.5 mg/kg organic selenium, the tissue selenium concentration was also higher at day 14 when compared with chick without any added selenium (0.1mg/kg). Couloigner *et al*. (2015) also established a

decline in FCR of chick from breeder hen fed seleno-hydroxy-methionine (0.2mg Se/kg) compared to chick from parent fed 0.3mg Se/Kg of sodium selenite and chick from parent on 0.2mg Se/kg yeast. The result also reported better FCR with a higher reserve of selenium at day-old for 0-21 days. The high selenium concentration of seleno-hydroxy-methionine in the muscle is an indication of better storage of seleno-hydroxy-methionine compare to other dietary treatments.

Tapiero *et al.* (2003) suggest that better Se storage in chicks supports better utilization of nutrients and has synergistic effect with liver α-tocopherol and vitamin A especially some days after hatching. Better FCR has also been reported with higher tissue selenium or hatch muscle selenium due to increased concentration of glutathione peroxidase in the liver (Wang *et al.*, 2011).

Kidd (2003) also reported that increasing dietary zinc concentration results in improved immunity and survivability. Combination of organic zinc and organic manganese in the diet of breeder hen was reported to reduced livability of up to day 34; immunity and heart beat were more in chicks (Virden *et al.,* 2004). Breeder hens fed rations containing organic Mn and organic Zn produced progenies with better breast meat compared to those supplemented with inorganic forms of same minerals.

2.4 Meat type chicken genotypes and preference in poultry market

Over the years, slow-growing broiler strains which reach a marketable weight in about 81 days have gained popularity in the European Union (EU) (Van Horne and Bondt, 2013). Kronsberg (2014) affirmed that these slow-growing strains make up a very small part of the chicken consumption in the United States since most of their use is within the culinary community where slower-growing breeds are touted as having a richer flavour. However, the use of slower-growing breeds may increase if methionine is removed from organic production or consumers continue to put pressure on retailers. Due to the interest in these slower-growing strains, a growing body of literature exists regarding the performance, meat quality and carcass characteristics of these strains. Rack *et al.* (2009) in assessing the outcome of self-selection feeding and pasture access on slow growing and modern broilers offered diets without synthetic methionine and reported that modern genotypes demonstrated superior carcass characteristics and growth indices. However, though the performance of modern birds were hindered

when housed on pastures, slower-growing birds did not experience a reduction in performance. Fanatico *et al*. (2008) researched on the comparative effect of different genotypes (slow-growing, medium-growing, and modern) reared intensively or extensively and posited that modern genotypes recorded a better breast meat percentage, while slow-growing genotypes had better wing and leg percentages. However, the protein and α –tocopherol content in the breast of slow growing strains were noticeably higher and they also had reduced lipid content compared to their modern conterpart. In a study comparing a slow-growing genotype (81-day grow out) to two medium-growing genotypes (67-day grow out) and a commercial fast-growing genotype (53-day grow out) raised either indoors or outdoors, Fanatico *et al.* (2005) found that slow-growing birds stay longer outside and had better activity than fast-growing birds. Rack *et al.* (2009) showed that access to pasture decreased performance for the fast-growing broilers while it does not affect the growth of slow-growing ones. In another experiment, where chickens were provided with a standard feed or a low-nutrient-density feed, slow-growing birds demonstrated reduced weight gain when offered a low-nutrient-density feed. However, birds from fast-growing genotypes increased their feed intake such that their body weight gain was unaffected, though breast yield was reduced and the birds exhibited poorer feed utilisation (Fanatico *et al*., 2008).

Fanatico *et al*. (2005) observed variation in meat quality of the genotypes with slow-growing birds having paler, less red-breast meat and the water holding capacity was poor relative to those from fast-growing birds. In the same experiment, a consumer panel considered meat from all treatments to be tender and weak in flavour with overall hedonics scores in the categories of "like slightly" or "neither like nor dislike". In a follow-up experiment, Fanatico *et al*. (2007) made a comparism between the fleshly qualities of chicken meat from a slow-growing genotype (91-day grow-out) to that of a fast-growing genotype (63-day grow-out) and found no significant differences in overall acceptability of consumer panel but described the meat from the slow-growing genotype as having substantial deeper fat flavour than the modern ones. However, Napolitano *et al.* (2013) noted that the preference for chicken breast meat is depends more on information on the production of the chicken than information on the sensory or organoleptic properties of the products. Therefore, providing information on product labels that suggests better production practices may increase consumer

preference for these products regardless of whether the consumer can perceive an actual difference in flavour or texture.

Additional research has been conducted to compare modern broilers with unselected, random-bred populations that have been maintained at various universities. While these birds are no longer used in the commercial industry, they represented an important resource which may help to identify and characterize the genetic changes that have taken place through intensive selection (Havenstein *et al*., 1994). The authors noted significant improvement in growth when compared to representative birds of randomly bred strains of the 1957 genetics versus an Arbor Acres bird which is representative of the 1991 genetics and Ross 308 which is representative of the 2001 genetics (Havenstein *et al.*, 2003). Schmidt *et al.* (2009) compared the rate of growth of the tissue of a heritage broiler line and a Ross 708 broiler. The heritage line which was a New Hampshire x Plymouth Rock cross developed in the 1950s to represent the typical broiler utilised during that time. The UIUC has been maintained as a random-bred population since its development. The Ross 708 line was introduced in the early 2000s as a high-yielding meat chicken.

Therefore, comparing these two lines provides insight into the changes that had followed due to preference for body weight and nutrient utilisation over the span of 50 years. While Schmidt *et al*. (2009) found no difference between the lines for body weight at hatch, the Ross 708 line exhibited significantly faster growth rates. The Ross 708 averaged a live weight of 1800 grams in 5 weeks after hatch while the heritage broiler had only 1000 grams during the duration. Additionally, Looking at specific tissues shows a change in tissue accretion. At 35 days, the chest muscle of the heritage line consisted of 0.09 of the body mass, whereas 18% of total body mass of Ross 708 is contributed to breast meat. Additionally, the intestinal length comparative to the bird's weight was longer in Ross 708 than in the heritage line. However, the heart muscle was smaller for the Ross 708 bird's relative to bird's weight. When birds of similar weight were compared, the UIUC birds had larger hearts to the Ross 708 birds. Greater feed efficiency was reported for Ross 708 than UIUC during the experiment.

Zuidhof *et al.* (2014) compared a commercial Ross 308 strain (representative of the genetic stock available in 2005) to two Alberta Uni. strains (one un-tampered since 1957, the other unselected since 1978). Birds were raised using modern dietary

techniques to 56 days and the outcome indicated that the 2005 broiler growth was 4 times more with a reduction in the feed conversion ratio by half from 1957 to 2005. Collins *et al.* (2014) raised a flock of 1955 meat-type chickens alongside a flock of 2012 broiler chickens (Cobb 500) and observed that the 1955 strain were significantly smaller at every age and exhibited a different body conformation. Specifically, the 1955 strain had prominently heavier feet, wings, relative internal organs, and feathers, and significantly smaller breast and leg muscles than the Cobb 500 broilers. Similar to previous findings, the Cobb 500 broiler had smaller organs to body weight ratios.

2.5. Dietary composition of shea butter

Generally, vegetable oils are made up of two basic components which are triglycerides and unsaponifiable matter. The maximum unsaponifiable content of any vegetable oil is 2% (Ibemesi, 2007) and are vitamins, phytosterols and other non-tryglycerides in the oil while the remaining 98% are mainly tryglycerides. The tryglycerides are composed of fatty acids that are predominantly present in oil and a small portion of glycerol which are similar for all the oils. The physico-chemical properties imposed on each oil or fat is dependent on the nature of tryglycerides that made up the oil

Shea butter is the fat (compact at environmental temperature) derived from the tree called *Vitellaria paradoxa*. However, it is very important due to the higher concentration of unsaponifiables and the reported component of fatty acids. Honfo *et al*. (2011) posited that it has a moisture percentage value of 4.90%, while Olaniyan and Oje (2007) noted that moisture percentage of sheabutter could be as low as 0.10%. However, remarkablely higher values of 8.4% to 14.5% was observed when the physico-chemical and microbiological characterisation of sheabutter sold in markets were determined. Kassamba (1997) stated that the moisture content of sheabutter used for soap and cream production is 0.05% while confectionary firms use shea butter with less than 0.25 moisture content. Carbohydrate and fat contents were 22.3g/100g dry weight and 75.0g/100g dry weight, respectively. Ash content ranged from 1.3% dry weight to 3.2% dry weight (Chukwu and Adgidzi, 2008). In their assessment of the mineral content of shea butter, Alhassan *et al.* (2011) reported that calcium value varies from 0.2 to 34.1mg/100g dry weigh; Sodium value fluctuated from 0.7 to 9.6 mg/100g dry weight, Iron value fluctuated from 0.5 to 6.7mg/100g dry weight, magnesium value fluctuated from 0 to 8.9 mg/100g dry weight, manganese content

fluctuated between 0-0.14 mg/100g on dry matter basis, zinc level fluctuated from 1.9 to 3.4 mg/100g dry weight, copper fluctuated at 0-1.5 mg/100g dry weight while potassium value is between 0 and 4.5 mg/100g DM.

The vitamin composition of sheabutter was investigated by Akihisa *et al*. (2010) and concluded that sheabutter should contain some carotenes due to its yellowish colour. The authors noted that shea butter composed mainly of triglycerides and unsaponifiable component which ranged from 1.2% to 17.6%. However, Adriaens (1943) observed variation in the unsaponifiable component of the fruit depending on its ripeness, period of the year and other environmental factors. Shea butter has higher values for the unsaponifiables compared to other vegetable oils.

Acid value can be used to determine the amount of degradation of the glycerides by lipases or due to exposure to high temperatures and/or light and the value ranged from 0mg KOH/g to 21.2mg KOH/g for shea butter. However, Nkouam *et al.* (2007) observed higher values of 128.2mg KOH/g in sheabutter removed using CO_2 from seeds stored for two years. Kassamba (1997) posited that the acid values of sheabutter used in soap and cream production should be 0.3mg KOH/g of oil while confectionary products must be below 9mg KOH/g. Badifu (1989) noted that the breakdown of trigycerides is also reliant on the degree of free fatty acid (FFA) and its value ranged from 1% to 10.7%. The maximum tolerable level of free fatty acid for shea butter used for soap and cream production is 1% while confectionary industry use shea butter that contain 3% free fatty acid (Kassamba, 1997). The duration of storage of shea nut elevate the acidity of the butter. The reported peroxide value for shea butter ranged from 0.5-29.5 mEqO2/kg (Dandjouma *et al*., 2009). Peroxide is the intermediate product formed in the course of O_2 addition to lipids.

Iodine value is the extent of oil saturation or unsaturation and it indicates its shelf life. Iodine value of shea butter ranged from 21.7mgKOH/g to 89.5 mgI_2/100g (Nkouam *et al*., 2007). Di Vincenzo *et al.,* (2005) posited that unsaturated fatty acids in shea butter are classified into three: polyunsaturated, diunsaturated and monounsaturated. Maranz *et al.* (2004) determined triglyceride composition using carbon number procedure and HPLC analysis and established that shea butter has varying fatty acid profiles. Akihisa *et al*., 2010 screened shea kernels from different origins and established that shea butter fat are made up of 16 fatty acids, but five of them are most dominant and this

included the unsaturated ones (i.e oleic, linoleic and arachidic acids) while the saturated ones are palmitic and stearic acids. The most copious fatty acids reported is oleic acid with range of between 37.2% to 60.7% while the second fatty acid is stearic acid and its value range is between 29.5% to 55.7% (Akihisa *et al*., 2010; Okullo *et al*., 2010). Oleic acid component of shea butters from Uganda are high, but stearic acid are also predominant in some areas in other West Africa countries. Okullo *et al*. (2010) noted a higher value for palmitic acid in shea butter as it ranged from 3.4% to 7.5%, but on an average, it was 4.4% while the percentage of linoleic acid is between 5.5% to 7.9%.

Linoleic acid is critical in nutrition because it forms an integral part of cell structure and are not synthesised by the body. Maranz and Wiesman (2004) noted that a value range of between 6 to 8% linoleic acid is found in shea butter. Akihisa *et al*., 2010 reported that arachidic acid is between 0.6% to 1.8% while Tholstrup *et al*., 1994 established a variation of 0.2% to 1.6% for linolenic. According to Wiesman *et al.,* (2003), climate and provenances significantly influenced the tocopherol content in Shea butter and established that tocopherol content ranged from 29 to 805ug/g, with α-tocopherol values of 64%. The author stated further that both α-tocopherol and total tocopherol content of the butter was directly proportional to the temperature around the region of the shea tree from where the butter was derived.

2.6 Nutritional composition of palm kernel oil

Palm kernel oil (also called adin agbon in southwesthern Nigeria) are extracted from the seed of oil palm (*Elaeis guineensis*). Oil palm contain the most abundant oil yield among all the oil seeds that are produced in the world. The major oil is the palm oil while the minor one is palm kernel oil. According to Ndukwu and Asoegwu, (2010), palm kernel oil production in the world stood at 4.36 billion kg as far back as 2005-2006. For every hectare of oil palm harvested, about 10 tonnes of oil palm fruit are produced of which the palm oil yield is about 3000 kg and the kernel produced is about 750 kg and the palm kernel oil stands at 250 kg. They are comparable to coconut oil in the configuration of fatty acid and they are the only major sources of lauric acid among vegetable oils. Although they are more saturated than palm oil, they do not contain cholesterol or trans fat. In their bid to improve milk yield, fatty acid composition and ruminal fermentation of grazing Holstein friesian cows, Giron *et al*.(2016) posited that

incorporation of palm kernel oil in the feed of grazing cows with a combination of corn oil at 40g/kg at a mixing ratio of 75:25 increased milk volume, changed the milk fatty acid profile and also reduced the methane production when compared to the control.
Palm kernel oil can be removed by the following techniques;
Solvent extraction method; this involve the use of n-hexane in removing the oil from the kernel. Solvent extraction can be classified into three operational steps: kernel pretreatment, oil extraction and solvent recovery. It is usually used in large scale operation of oil extraction.Yerima *et al*. (2018) observed varying physico-chemical characteristics in the oils obtained with various extraction methods and also concluded that although, solvent extraction gives the highest oil yield at 51.35% compared to 16% for traditional and 40.02% for mechanical but the oils from solvent extraction are particularly suitable for soap industry due to its improved chemical characteristics. Oil obtained by solvent extraction are usually yellow in colour due to lower heating temperature (about 70^{o}C).

Mechanical extraction is appropriate for small and large scale operations and the processing can be classified into: pre-treatment of harvested seed, pressing of kernel and oil clearing up. A detailed description of palm kernel oil extraction through mechanical method included the selection of good kernel nuts, crushing of the nuts with the nut crusher, heating the seed with mechanical seed fryer so as to excite the oil molecules. The heated seed is then transferred to the oil press which then press out the oil from the heated seeds through the oil exit and expels the cake through the cake exit chamber.

2.7. Vitamin E and its contribution to fertility and hatchability of broiler breeder eggs

The fecundity of eggs are of significant interest in broiler breeders. Chicken egg contains significant amount nutrients such as carbohydrates, proteins, fats, vitamins and minerals, which can be influenced by dietary composition. Vitamin E, like other natural antioxidants is critical in the reproductive function of poultry as it helps in maintaining embryonic tissues; optimal antioxidant supplementation has been reported to help in maintenance of high productivity and improve the reproductive performances of poultry species (Surai *et al.,* 2006). However each specie of poultry

behave differently in the absorption of dietary vitamin E into the eggs and thus the embryo; the highest dietary transfer of α-tocopherol was observed in chickens when compared to other poultry species (Surai *et al.,* 1998). Developing embryo requires vitamin E which is mainly stored in the egg yolk as the main antioxidant (Surai, 1999). Surai (2002) reported that vitamin E absorption efficiency is determined by its dietary composition, inclusion level, age of the animal, sex of the animal and other physiological characteristic. Vitamin E is also considered chain breaching antioxidant in membranes existing as 4 tocopherols and 4 tocotrienols. Tobias *et al.* (1992) has reported that tocopherol inclusion in the ration has increased hatchability and had a direct correlation with hatching percentage (r=0.74) in the first 7 days of inclusion. Higher hatchability was reported when birds were offered 120 mg of dietary vitamin E/Kg compared with birds on 30mg/kg of vitamin E at 29 weeks but egg production was insignificant between the treatments (Urso *et al.,* 2015). Though, some researchers (Lin *et al*., 2004; Hooda *et al*., 2007) still believed higher dietary vitamin E levels has no beneficial role in the reproductive efficiency of poultry.

2.7.1 Dietary Vitamin E and broiler breeder male fertilising potentials

The spermatozoa of chicken have a high percentage of multiple carbon polyunsaturated fatty acids (PUFA), which are crucial in the maintenance of membrane integrity such as volatility and plasticity. However, increased proportion of PUFA result in the spermatozoa becoming subseptible to lipid peroxidation which vitamin E can help to prevent with it antioxidant properties thus maintaining the quality of the semen. (Surai *et al.,* 2006). Vitamin E enhanced fertility in different farm animals. It can be deduced that there is a direct relationship between male fertility and semen or spermatozoa qualities, concentration of the sperm cells, semen volume, sperm viability and motility among others. The qualities mentioned above are however affected by factors such as environmenal factors and endocrine disturbing chemicals which may come in contact with the cock by touching the skin, nutrition or during respiration. Minerals, vitamins and antioxidant could however be added to diets or through clinical treatment to reverse the adverse effects. (Rengaraj *et al*., 2015).

Linoleic acid belong to class of essential fatty acid that can't be synthesised *de novo* in vertebrates.Diets supplemented with linoleic acids requires the addition of antioxidants

to prevent deterioration of fatty acid due to oxygen addition (Rengaraj *et al.,* 2015). Arscott *et al*. (1965) fed diets with high concentration of linoleic acid together with low (4.3mg/kg) or high (166.3mg/kg) vitamin E level supplemented in the diet of white leghorn males for a period of 25 weeks and observed a decreased fertilizing capability and lower spermatozoa count in males fed ration supplemented with higher linoleic acid and lower vitamin E.

Mokadi and Budowski, (1963) noted that vitamin E prevent lipoperoxidative damage and protects chickens from encephamalacia by inhibiting the formation of keto acids from linoleic acid breakdown, and this is more prominent in chickens on high polyunsaturated fatty acid (PUFA) supplemented feed but lower tocopherol. The detrimental consequences of excessive linoleic acid dietary concentration on spermatogenesis in males can be reversed with the administration of vitamin E as reported by Arscott and Parker (1967). Dilauryl succinate though do not contain peroxide or PUFA, but also induces encephalomalacia in chickens.

Avian spermatozoa have higher concentrations of PUFA, especially, docosatetraenoic acid and arachidonic acid (Surai *et al*., 2001). Polyunsaturated fatty acids function in ensuring membrane flexibility and promotion of sperm mobility and fusion. Spermatozoa are particularly prone to lipoperoxidative damage due to the high concentration of PUFA which may result in the release of free radicals, therefore, an increased level of antioxidant can reverse the trend. In the study conducted by Surai *et al*. (2001) with Rhode Island Red chickens fed diets containing graded inclusion of α-tocopheryl acetate; the authors observed elevated vitamin E content in semen and spermatozoa, with reduced vulnerability of the spermatozoa to peroxidation particularly in chickens on 200mg/kg Vitamin E. Zanini *et al*. (2003) posited that spermatozoa are more effective, motile and move faster when 38 weeks old white Leghorn males were placed on a diet supplemented with soyabean oil, combined with tocopherol.

Biswas *et al*. (2009) noted that vitamin E content in seminal fluid was higher in chickens on 100mg/kg vitamin E compared to those on 10mg/ kg. These studies positively relate the antioxidant status of semen to the dietary antioxidant content. Hooda *et al.*(2007) supplemented male Japanese quail with diets having varying

inclusions of tocopherol from five weeks and concluded that the quails on 75 IU/kg feed produced the highest fertility.

Selenium is a micro element which are usually included in the diets to boost and maintain reproductive functions. Dietary selenium deficit could result in lowered spermatozoa motility, count and fertilising ability in poultry as selenium is an integral part of selenoproteins, such as glutathione peroxide whose major functions is to protect sperms from oxidative damage. Vitamin E interaction with selenium result in the maintenance of reproductive system as well as in the prevention of the release of free radicals. The blend of both selenium and tocopherol result in the improvement in reproductive functions of poultry birds when supplemented in the diet, especially in those species that have low reproductive behaviour, Supplementation of feed with antioxidants is an important condition for achieving and sustaining good fertility. Lin *et al*. (2005) observed that Taiwan Native male chickens fed corn/ soyabean diets for 23 weeks had a significantly higher spermatozoa viability, amount and movement, and in the semen of those on vitamin E supplementation.

2.7.2 Dietary Vitamin E and broiler breeder female fertility

The fertilising ability of hens together with the roosters play important role in the final hatching of healthy chicks. In commercial broiler production system, hen day production as well as the egg superiority characteristics, including egg mass, internal egg qualities, and the egg fecundity and hatchability are critical elements required for healthy chicks. The productivity of the breeding industry will be determined based on the number of egg transferred for hatching (Khan, 2011).

The nutritional composition of eggs has a positive correlation with the health of the chicks that are hatched. The nutrients stored in egg is a complete profile, including energy, amino acids, fats, vitamins, and minerals, and the profile can be varied by changing the dietary composition of hens. In chickens fed normal diets, the concentrations of fatty acids and water insoluble vitamins are relatively stable in the eggs. However, they can be altered by dietary supplementations which can affect the nutrient profile. In a bid to ascertain the importance of nutrient variation on fertility, Machlin *et al.* (1962) fed white leghorn hens with diets containing 7% of linoleic acid and 20IU/pound vitamin E over a duration of 56 days. The report stated that, hen day

egg production had declined to 25% from a previous 78%. Egg fertility was 37%, and zero hatchability was reported. When their diets were supplemented with higher quantities of antioxidant (100 IU/pound VE in feed) and linoleic acid (7%) for 56 days, the hen day egg production improved to 57% while the fertility stood at 76% and hatchability was 67%, and he concluded that vitamin E being an antioxidant, protect female fertilising ability by inhibiting the oxidation of linoleic acid. Also, the report emphasised that hens placed on feed with lower polyunsaturated fatty acid require no supplemental oxygen scavenger for preservation of egg output, fecundity, and hatchability.

Vicine, an alkaloid that can be extracted from faba beans (Vicia faba L.), was observed to be important in the breakdown and absorption of nutrients in laying hens. Dietary vicine caused peroxidative damage to cellular components, thereby causing disproportionate fat uptake and a decreased fecundity. Muduuli *et al*. (1982) fed a diet mixed with the alkaloid to white leghorn hens and observed a reduced egg mass, increased infertility and lower hatched chicks. However, vitamin E supplementation marginally improved the egg mass and significantly improved the total number of hatched chicks per egg set. It can be deduced from the report of the study that vitamin E might be critical in neutralising the negative binding effect of the toxic alkaloid. Similar to the report earlier stated, a sufficient quantity of vitamin E is important in the chicken feed for preserving fertilising ability of the hens irrespective of the composition of the feed.

In the research conducted by Lin *et al.,* (2004) on local chicks from Taiwan, they were offered with corn/soyabean diet over a 119 day period. The pullets were then classified into groups with some being offered diets supplemented with 80mg/kg VE. The authors observed a better output with respect to egg number and weight in the VE supplemented group. Also, the vitamin E supplemented group had an improved fertility of over 7% and hatchability of over 13%. In a study to understand how vitamin E supplementation can affect quail reproductive performance, Hooda *et al.* (2007) classified 35 days old Japanese quails into groups and placed them on the following graded diets (0, 67.5, 135, 202.5, and 270 mg dl-α-tocopheryl acetate/kg feed). The males and females quails were then grouped accordingly: males and females without supplementation, non-supplemented males with supplemented females, non-supplemented females with supplemented males and supplemented males and females.

In his report, males and females on vitamin E supplemented diet had an improved hatched quail per unit of egg set compared to others. However, their observation were unchanged by additional dietary vitamin E inclusion. The chicks output of female Japanese quails placed on low vitamin E based diets over a prolonged period of time is often low. However no other quantifiable signs were observed.

In the roosters, the spermatozoa are deposited for a brief period in the vas deferens. After ejaculation, the ejaculate is screened and the vetted spermatozoa are deposited for an extended period at two sperm storage tubules within the female reproductive tract. Dietary vitamin E enhance the sperm storage sites in hens due to its antioxidant capacity. The authors observed a positive correlation between the spermatozoa count at the utero-vaginal junction and those found at the perivitelline layer of eggs. However, effective fertilisation of egg occur when spermatozoa count on the perivitteline layer exceeds 1440.

CHAPTER THREE

3.0 MATERIALS AND METHODS

Study one: Chemical characterisation of sheabutter, sesame seed oil and palm kernel oil

Selected lipids

3.1 Experimental Site

The research was accomplished at the Central Nutrition Laboratory of Animal Science Department, University of Ibadan, Ibadan, Nigeria located in the tropical rain forest zone of Nigeria within the latitude 7^{o}26.05 N and longitude 3^{o}54.74 E, and an average altitude of 277 meters above sea level. Temperature range and average relative humidity of the location were between 20-35^{o}C and 60%, respectively

3.2 Selected samples

Three lipids, sheabutter (SB), sesame seed oil (SSO) and palm kernel oil (PKO) were selected for the experiment. The basis for their selection was based on:

Their frequency of usage in the poultry industry

Their relative availability and price of lipids

Their documented vitamin E composition in literature (Akihisa *et al*., 2010; David *et al*., 2001)

3.3 Sample collection

Palm kernel oil (PKO) was purchased at a palm kernel mill in Challenge area in Ibadan as finished product and they were purchased per batch with each batch representing each week of the experiment, while shea butter (SB) was purchased at the open market in Oja-oba in Ibadan from a single supplier and they were purchased per batch with each batch representing each week of the experiment. Sesame seed oil (SSO) was

purchased at Bodija market in Ibadan from a single source and it was purchased per batch with each batch representing each week of the experiment.

3.4 Determination of peroxide value of oils

The peroxide values of the PKO, sheabutter and sesame seed oil were carried out by titration according to AOAC (2000). The peroxide values were then calculated by the formulae (AOAC, 2000; Nielsen, 2002).

PV = A x V

Where: PV = Peroxide value, V = Vol of $Na_2S_2O_3$ used, A = (N x 1000) / W,

N = Normality of $Na_2S_2O_3$, W = Weight of oil

3.5 Determination of iodine value

Iodine values of the PKO, SB and SSO were carried out by titration according to AOAC, (2000). The iodine values were then calculated by the equation below (AOAC,2000; Nielsen, 2002). The experiment were carried out in triplicates.

$$IV = \frac{[(V_2 - V_1) \times M \times 12.7]}{W}$$

Where: IV = Iodine value, V1 = Amount of $Na_2S_2O_3$ in cm^3 used for the oil V2 = Amount of $Na_2S_2O_3$ cm^3 used for the blank, M = Molarity of $Na_2S_2O_3$used, W = Weight of oil used.

12.7 = ~ constant used to convert from milliequivalent thiosulphate to gram (Molecular weight of Iodine = 126.9)

3.6 Determination of saponification value

The saponification value of the PKO, SB and SSO were carried out by titration according to AOAC (2000). The saponification value were then calculated by the formulae (AOAC, 2000; Nielsen, 2002).

$$SV = \frac{[(V_2 - V_1) \times M \times 56.1]}{W}$$

Where: SV=Saponification value, V_1=Amount of HCl used in cm^3 for the oil,

V_2 = Amount of HCl used in cm^3 for the blank,

M = Molarity of the HCl, W = Weight of oil used,

56.1 = Molecular weight of KOH.

3.7 Determination of acid value

The acid value of the PKO, SB and SSO samples were carried out by titration according to AOAC (2000). The acid value were then calculated by the formulae (AOAC, 2000; Nielsen, 2002).

$$AV = \frac{[T \times M \times 56.1]}{W}$$

Where: AV = Acid value, T = Volume of NaOH, M = Molarity of NaOH, W= Weight of oil, 56.1 = Molecular weight of KOH

3.8 Determination of fatty acid profile

Determination of fatty acid component of the oils were carried out by the method of AOAC (2000) in triplicates using the gas chromatography (GC) at a detector temperature of 200^{o}C at the central laboratory, University of Ibadan, Ibadan, Nigeria.

3.9 Determination of α-tocopherol

The tocopherol composition of oils were carried out by the method of AOCS (2003) using HPLC at 292 nm. The experiment was repeated three times

3.10 Determination of total carotene

The total carotene of oil samples was determined according to AOAC (2000), using spectrophotometer at 440 nm

3.11 Statistical Analysis

Data were subjected to general linear model of Analysis of Variance (SAS, 2002) at $\alpha_{0.05}$. Means were separated using Duncan multiple range test of the same software.

Study Two: Effect of dietary vitamin e supplementation on fertility and hatchability of broiler breeder eggs

3.12 Experimental site

The research was conducted at the Poultry Unit, Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria located in the tropical rain forest zone of Nigeria between the latitude 7^{o} 26 N and longitude 3^{o} 54 E with a mean altitude of 277 meters above sea level.

3.13 Experimental animals and management

Thirty weeks old Arbor Acres plus broiler breeder hens (n=180) and eighteen cocks with standard husbandry records were procured from a reputable farm and the hens were allocated to 6 dietary treatments. Each of the treatment were repeated five times with six birds per unit using Experimental Animal Allotment Program, EAAP (Kim and Lindermann, 2007). The cocks were not allotted to treatment, the semen were collected and pooled together before being used for insemination. The experimental birds were confined in a 3-layer battery cage. Each compartment had a dimension of 50 x 45 x 40 cm^3 and floor measuring 900 cm^3 that housed two chickens. The experimental birds were weighed at inception and weekly weight gain throughout the experimental period were recorded. Regular activities such as vaccination and drug administration were followed as prescribed while diets and water were provided according to specification in the Arbor Acre broiler breeder production manual. The study lasted eight weeks and the composition of the diet used for the study is presented in Table 3.2

3.14 Gross composition of experimental diets

The experimental diet of the Arbor Acres plus broiler breeders were calculated to adhere to the nutritional requirement of the chickens as stated in the breeder manual of Aviagens for Arbor Acre plus broiler breeder. Test ingredients were added as overage to the feed and the dietary layout of the experiment is presented in Table 3.1.

3.15 Experimental design and dietary layout

The experimental design is a completely randomised design and details of the dietary layout is presented in Table 3.1.

3.16 Statistical model

$$Yij=\mu+\tau i+\in ij$$

Where

μ= common effect of the experiment

Yij= j-th observation on the i-th treatment

τi= the i-th treatment effect,

$\in ij$ = random error present in the j-th observation in the i-th treatment

Table 3.1: Layout of broiler breeder hens fed varying dietary inclusion of vitamin E

Diet	Inclusion level of α-tocopherol (IU/kg)
Treatment 1	Basal diet
Treatment 2	Basal diet + 20
Treatment 3	Basal diet + 40
Treatment 4	Basal diet + 60
Treatment 5	Basal diet + 80
Treatment 6	Basal diet + 100

Table 3.2: Gross composition (g/100g) of diets fed to broiler breeder hen

Ingredient	0 IU/kg	20 IU/kg	40 IU/kg	60 IU/kg	80IU/kg	100IU/kg
Corn	65.42	65.42	65.42	65.42	65.42	65.42
SBM	21.15	21.15	21.15	21.15	21.15	21.15
Wheat offal	5.63	5.63	5.63	5.63	5.63	5.63
Limestone	8.22	8.22	8.22	8.22	8.22	8.22
DCP	1.64	1.64	1.64	1.64	1.64	1.64
Salt	0.33	0.33	0.33	0.33	0.33	0.33
vitamin-mineral premix	0.20	0.20	0.20	0.20	0.20	0.20
Methionine	0.15	0.15	0.15	0.15	0.15	0.15
Lysine	0.01	0.01	0.01	0.01	0.01	0.01
α-Tocopherol (10^{-3})	-	1.8	3.6	5.4	7.2	9.0
Metabolisable energy (Kcal/KG)	2828.00	2828.00	2828.00	2828.00	2828.00	2828.00
Crude protein (%)	15.48	15.48	15.48	15.48	15.48	15.48
Phosphorus (%)	0.40	0.40	0.40	0.40	0.40	0.40
Calcium(%)	3.20	3.20	3.20	3.20	3.20	3.20

SBM; Soya bean meal: DCP;Di calcium phosphateMeans with different superscripts are significantly different ($P<0.05$) SEM – Standard Error of Means: VIT A 10 000IU, VIT D3 2500IU, VIT E 50 IU, VIT k3 2.5mg, VIT B1 2.5mg, VIT B2 8mg, VIT B6 0.015mg, Nicotinic Acid 45mg, Panthotenic acid 15mg Choline 1400mg Biotin 0.2mg, Folic acid 1.5mg, cu 8mg, fe 80mg, Zn 70mg, Mn 95mg, Se 0.18mg, I 0.35mg

3.16 Data collection

3.16.1 Internal and external attributes of egg

At weeks 34 and 38 of age, 60 eggs that had been stored for seven days representing 10 eggs per treatment were sampled for internal and external egg characteristics. The weight (grams) of eggs were obtained using a digital scale while egg width (cm) and egg length (cm) were obtained with Vernier caliper (Mitech Metrology ltd, China). The thickness of the shell was determined with a micrometer screw gauge (Ames, Waltham, MA, USA) at three different locations (broad, middle and small ends of each) as described by Tyler (1961). To obtain the egg shell weight, the egg content were emptied, the shell was washed thoroughly in running water and dried for two hours at 105 °C with the shell membrane intact, it was then weighed on an analytical scale (Kirikci *et al*., 2003).

Internal egg characteristics were determined by breaking the eggs on a horizontal surface. The yolk was prudently removed from the albumin using a clean spoon for measurement. Albumen diameter and yolk diameters were determined with a digital vernier caliper (Mitech Metrology Ltd, China). The yolk weight was measured by placing it in a petri-dish of known weight and the weight of both the yolk and the petri-dish were measured on a digital scale and then subtracted to get the yolk weight alone. Albumin height was measured 1cm away from the yolk edge and the height of the sticky fluid on the tip was adjusted to read the height on the digital screen of the vernier caliper while the yolk height was obtained by dipping the pointed edge of the vernier caliper through the middle of the yolk. The albumen weight was obtained by deducting the weights of the yolk and that of the shell from that of egg (Kirikci *et al*., 2003). The Haugh unit (HU) was obtained by the equation described by Haugh (1937) as shown below:

$HU = 100 \log_{10} (h - 1.7W^{0.37} + 7.6)$ where

HU = Haugh unit

h = albumen height (millimeter)

W = egg weight (grams)

The same procedure was adopted for internal and external egg characteristics in study 3.

3.16.2 Determination of α-tocopherol

The α-tocopherol deposition in the eggs of the hens were determined according to AOAC (2000) in triplicate using HPLC at 292 nm. The same procedure was adopted for α-tocopherol determination in study 3.

3.16.3 Determination of total carotene

The total carotene deposition in the eggs of the hens were determined according to AOAC (2000), using spectrophotometer at 440 nm. The same procedure was adopted for total carotene determination in study 3.

3.16.4 Performance characteristics

Hens in each of the replicates were weighed at the commencement of the experiment and also weekly to obtain the mean average body weight. Egg weight was determined using a laboratory digital scale of 0.01g accuracy.

The number and weight of eggs produced per replicate for each treatment were documented daily while Hen-day egg percentage was calculated as follows:

$$\text{Hen Day Egg Production} = \frac{\text{Total number of eggs produced per week}}{\text{Total number of hens}} \times 100$$

Average egg mass was determined by using the relationship between the hen day egg production and the average weight of the representative samples of eggs produced per replicate as shown:

Average egg mass (g/hen/day) = % Hen-day egg production x Average egg weight (g).

Feed conversion ratio per egg mass (FCR/EM) was determined by taking into consideration the feed intake (g), Hen-day egg production (%), egg weight and the calculation is presented below:

$$\text{FCR} = \frac{\text{Feed consumed}}{\text{Average egg mass}}$$

The same procedure was adopted for performance characteristics in study 3

3.16.5 Determination of egg produced, egg set, transferred, hatched, fertility and hatchability percentages

The egg produced were determined by pooling together of all the eggs laid by the hens per replicate per week which were stored at an optimum temperature of 16^{o}c as according to North and Bell (1990). The egg set was determined by physically observing the eggs to separate those eggs which were not settable such as those that had cracks, too big for the setter crates and those with too soft or too hard shells. The eggs transferred were obtained by candling of the egg at day 18 of incubation by placing them in a candling machine to separate the fertile eggs from the infertile ones. The hatched were determined by separating the hatched chicks from the unhatched eggs. Fertility and hatchability were calculated according to the formulae below

$$\text{Fertility} = \frac{\text{Number of egg transferred}}{\text{Number of egg set}} \times 100$$

$$\text{Hatchability} = \frac{\text{Number of hatched chicks}}{\text{Number of egg transferred}} \times 100$$

The same procedure was adopted for production efficiency determination in study 3.

3.16.6 Blood sample collection and evaluation

At the end of the experiment (week 38 of age), 5 ml of blood samples were collected from three hens per replicate. To obtain the blood samples, jugular venipuncture was performed on each hen and 2 mL of the blood were released into ethylene diamine tetra acetic acid (EDTA) bottles for haematological assay and 3 mL into EDTA free bottles for serum biochemical analysis, respectively. The same procedure was adopted for blood sample collection and evaluation in study 3.

Haematological indices

The blood samples which were collected into the EDTA bottles were used to determine the haematological indices. Packed cell volume (PCV), blood cell counts (RBC and WBC), and haemoglobin concentration (Hb) were assayed according to Lamberg and Rothstein (1977). The following parameters were calculated with standard formula:

$\text{MCV (fl)} = (\text{PCV} \times 10) / \text{RBC}$,

$\text{MCH (pg)} = (\text{Hb} \times 10) / \text{RBC}$ and

MCHC (g/l) = (Hb x 100) / PCV.

Serum biochemical parameters

The blood in the EDTA free bottles were allowed to coagulate and the sera harvested after centrifuging at 3500 rpm for 10 minutes. The parameters assessed included catalase, superoxide dismutase activities by colorimetric method (Sinha, 1972; Kakkar *et al*., 1984). Serum lipids such as triglycerides (Trinder's enzymic method), Total cholesterol (Gowenlock *et al*., 1988) were also determined by automatic analyser (Kodak Ektachem; Eastman Kodak Company, Rochester, New York). Sample reading were in triplicates using a spectrophotometer with wavelengths specific for each parameter and the kits used for the assay were purchased from Cayman Chemical company, Michigan, U.S.A

3.16.7 Statistical Analysis

Data were subjected to general linear model of Analysis of Variance (SAS, 2002) at $\alpha_{0.05}$. Means were separated using Duncan multiple range test of the same software.

Study three: Effect of shea butter and palm kernel oil on fertility and hatchability of eggs from broiler breeder hens

3.17 Experimental site

The research was conducted at the Poultry Unit, Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria located in the tropical rain forest zone of Nigeria within the latitude 7^{o} 26 N and longitude 3^{o} 54 E with a mean altitude of 277 meters above sea level.

3.18 Experimental animals and management

Arbor Acre plus broiler breeder chickens (n=200) at week 42 of life with standard husbandry records were procured from a reliable farm in Ibadan. They were allocated to 8 dietary treatments. Each treatment was repeated five times with five birds per replicate. The cocks were not allotted. Both the hens and cock were accommodated in a 3-layer battery cage. Each compactment had a dimension of 50 x 45 x 40 cm^3 and a floor measuring 900cm^3 which housed two chickens. Both the cocks and the hens were weighed at inception and weekly throughout the duration of the experiment. Regular

activities such as vaccination and drug administration were followed as prescribed while diets and water were provided according to specification of Arbor Acres broiler breeder production manual. The study lasted eight weeks.

3.19 Gross composition of experimental diets

The experimental diet of the Arbor Acres plus broiler breeders were designed to cater for the nutritional requirement of the chickens as stated in the breeder manual of Aviagens for Arbo Acre plus broiler breeder. The diets were isocaloric and isonitrogenous and the dietary details is presented in table 3.4.

3.20 Experimental design and dietary layout

The design is a completely randomised design and the details of the experimental layout is presented in table 3.3 below:

3.21 Statistical Analysis

Data were subjected to general linear model of Analysis of Variance (SAS, 2002) at $\alpha_{0.05}$. Means were separated using Duncan multiple range test of the same software.

Table 3.3: Layout of broiler breeder hens fed varying dietary inclusion of shea butter and palm kernel oil

Diet	VitaminE supplementation	PKO inclusion (%)	SB inclusion (%)
Treatment 1	Basal diet	-	-
Treatment 2	Basal diet +optimum VE (37 IU/kg)	-	-
Treatment 3	Basal diet	1.5	-
Treatment 4	Basal diet	3	-
Treatment 5	Basal diet	4.5	-
Treatment 6	Basal diet	-	1.5
Treatment 7	Basal diet	-	3
Treatment 8	Basal diet	-	4.5

Table 3.4: Gross composition (g/100g) of diets fed to broiler breeder hen

Ingredient	0 IU	37IU	1.5%pko	3%pko	4.5%pko	1.5%sb	3%sb	4.5%sb
Maize	65.4	65.4	63.4	61.4	59.4	64.1	61.2	59.8
PKO	-	-	1.5	3.0	4.5	-	-	-
SB	-	-	-	-	-	1.5	3.0	4.5
Tocopherol (10^{-5})	-	3.3	-	-	-	-	-	-
Wheat bran	5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.60
Limestone	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20
D.C.P	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
SBM	21.20	21.20	21.00	20.80	20.70	20.90	20.60	20.50
Choline chloride	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Lysine	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Methionine	0.20	0.20	0.20	0.20	0.15	0.15	0.15	0.15
Breeder premix	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Crude protein (%)	15.20	15.20	15.00	14.80	14.60	15.00	14.80	14.60
Met energy(kcal/kg)	2714.60	2714.60	2807.90	2898.70	2986.00	2803.80	2890.50	2974.70
Calcium	3.30	3.30	3.30	3.20	3.10	3.30	3.20	3.20
Phosphorus	0.40	0.40	0.40	0.40	0.38	0.40	0.40	0.40

SBM; Soya bean meal: DCP;Dicalcium phosphate Means with different superscripts are significantly different ($P<0.05$) SEM – Standard Error of Means: VIT A 10 000IU, VIT D3 2500IU, VIT E 50 IU, VIT k3 2.5mg, VIT B1 2.5mg, VIT B2 8mg, VIT B6 0.015mg, Nicotinic Acid 45mg, Panthotenic acid 15mg Choline 1400mg Biotin 0.2mg, Folic acid 1.5mg, Cu 8mg, Fe 80mg, Zn 70mg, Mn 95mg, Se 0.18mg, I 0.35m

CHAPTER FOUR

4.0 RESULTS

4.1 Chemical characteristics of sheabutter, palm kernel oil and sesame seed oil

The chemical characteristics of sheabutter, palm kernel oil and sesame seed oil are obtainable in Table 4.1. The iodine values of the three lipids under consideration were similar ($p>0.05$). However, the saponification value of palm kernel oil (249.90±12.08 mgKOH) was significantly higher than that of shea butter (190.89±9.12 mgKOH) and sesame seed oil (15.80±4.30 mgKOH). Also, the peroxide value of 7.41±3.34 meq/kg in Sheabutter was noticeably higher ($p<0.05$) compared to 0.74±0.31 meq/kg in palm kernel oil and 0.34±0.2 meq/kg in sesame seed oil. The degree of free fatty acid present in palm kernel oil was higher ($p<0.05$) than that of shea butter and sesame seed oil and this reflected in the higher acid value that was observed in palm kernel oil (25.29±2.46 mgKOH/g) when compared to that of shea butter (10.65±1.00 mgKOH/g) and sesame seed oil (17.21±3.22 mgKOH/g).

4.1.1 Total carotene and α-tocopherol of sheabutter, palm kernel oil and sesame seed oil

The total carotene and α-tocopherol composition of sheabutter, palm kernel oil and sesame seed oil are shown in Table 4.2. The α-tocopherol concentration in shea butter was higher 119.18±1.25 µg/mL when compared to palm kernel oil which had 24.37±1.25 µg/mL and sesame seed oil which had 69.57±2.23 µg/mL. Sheabutter (7533.20±264.09 µg/mL) also contained more total carotene $p<0.05$ than palm kernel oil which had 3041.10±144.01 µg/mL and sesame seed oil with total carotene concentration of 4624.30±107.31 µg/mL.

4.1.2 Fatty acid profile of sheabutter, palm kernel oil and sesame seed oil

The fatty acid composition of palm kernel oil, sheabutter and sesame seed oil are presented in Table 4.3. Shea butter does not have caproic, caprylic, capric and behenic acids while sesame seed oil does not have caproic, caprylic, capric, lauric, linolenic and palmitoleic acids. Palm kernel oil does not contain arachidonic, linolenic, palmitoleic and behenic acids. Palm kernel oil which is also called lauric oils had a significant component ($p<0.05$) of lauric acid which was 43.55±0.9 compared with 0.74±0.06% in Shea butter while sesame seed oil does not have lauric acid at all.

Sesame seed oil contained a relatively low myristic acid content of 0.16±0.06% compared to 0.26±0.04% observed in sheabutter and 22.31±0.60% in palm kernel oil. However, stearic acid was noticeably reduced ($p<0.05$) in palm kernel oil (2.64±0.10%) and sesame seed oil (5.80±0.30) when compared to Shea butter which had 42.47±0.86%

Sesame seed oil contained a relatively greater ($p<0.05$) composition of unsaturated fatty acids content compared with PKO and sheabutter. The linoleic acid composition of sesame seed oil was 42.63±0.75 compared to shea butter and palm kernel oil which contained only 5.57±0.04% and 1.07±0.05% respectively. However, shea butter contain a higher percentage of oleic acid at (44.82±0.02%) when compared to that of palm kernel oil (4.88±0.10%) and sesame seed oil (41.09±1.62). Sheabutter also contained arachidonic acid of 1.15±0.03% which is significantly higher than 0.63±0.12 in sesame seed oil but it is not contained in palm kernel oil. Sheabutter also contained a linolenic acid content of 0.25±0.01% which is not present in both palm kernel oil and sesame seed oil.

4.2 Internal attributes of eggs from broiler breeder hens fed varying dietary levels of supplemental vitamin E

Internal attributes of eggs of Arbo acre plus hens offered varying dietary inclusions of supplemental tocopherol is as presented in Table 4.4. The treatment with 40 IU/kg and 60 IU/kg of supplemental α-tocopherol had the highest Haugh units of 82.71±4.71 and 83.97±3.55, respectively. There were no substantial variation in the Haugh unit ($p>0.05$) of the treatments supplemented with 20 IU/kg (80.82±4.59), 80 IU/kg (77.30±11.30) and

100 IU/kg (80.90±3.50). However, the treatment without supplemental vitamin E had the lowest ($p<0.05$) Haugh unit of 69.32±15.42 when matched with the other treatments.

The yolk height, yolk diameter, albumen weight and yolk weight were not affected ($p>0.05$) by the inclusion of supplemental viatmin E in the diet of broiler breeder hens. There were no noticeable effect of treatment ($p>0.05$) on yolk height, yolk diameter, albumen weight and yolk weight and none of the treatments followed any particular pattern. Albumen height were expressively higher ($p<0.05$) at 40 IU/kg (7.29±0.73cm) and 60 IU/kg (7.24±0.66cm) supplemental vitamin E inclusion. However, eggs collected from the control treatment (i.e diets without any supplememntation) had the lowest albumen height of 5.64±1.65cm. Other treatments however had similar ($P>0.05$) albumen height.

Table 4.1: Chemical characteristics of sheabutter, palm kernel oil and sesame seed oil

Parameters	PKO	SB	SSO
Saponification (mgKOH)	249.90±12.08[a]	190.89±9.12[b]	15.80±4.31[c]
Iodine (g/100g)	4.74±1.43	4.83±3.69	6.94±4.20
Peroxide (meq/kg)	0.74±0.31[b]	7.41±3.34[a]	0.34±0.24[b]
Acidity (mgKOH/g)	25.29±2.46[a]	10.65±1.00[c]	17.21±3.22[b]

[ab] Means with different superscripts along the row are significantly different ($p<0.05$); PKO-Palm kernel oil; SB-Sheabutter; SSO-Sesame seed oil

Table 4.2: Total carotene and α-tocopherol of sheabutter, palm kernel oil and sesame seed oil

PARAMETER	PKO	SB	SSO
α-tocopherol (µg/mL)	24.37 ± 1.25^{c}	119.18 ± 1.25^{a}	69.57 ± 2.2^{b}
Total carotene (µg/mL)	3041.10 ± 144.01^{c}	7533.20 ± 264.09^{a}	4624.30 ± 107.3^{b}

[ab] Means with different superscripts along the row are significantly different ($p<0.05$) ; PKO-Palm kernel oil; SB-Sheabutter; SSO-Sesame seed oil

Table 4.3: Fatty acid profile of sheabutter, palm kernel oil and sesame seed oil

FATTY ACID	Palm kernel oil %	Sheabutter %	Sesame seed oil
Caproic	0.79±0.01[a]	ND	ND
Caprylic	10.49±0.50[a]	ND	ND
Capric	6.99±0.10[a]	ND	ND
Lauric	43.55±0.90[a]	0.74±0.06[b]	ND
Myristic	22.31±0.60[a]	0.26±0.04[b]	0.16±0.06[b]
Palmitic	7.82±0.10[a]	4.01±0.03[b]	9.20±0.10[a]
Stearic	2.64±0.10[b]	42.47±0.86[a]	5.80±0.30[b]
Oleic	4.88±0.10[b]	44.82±0.02[a]	41.09±1.62[b]
Linoleic	1.07±0.05[b]	5.57±0.04[a]	42.63±0.75[a]
Arachidonic	ND	1.15±0.03[a]	0.63±0.12[a]
Linolenic	ND	0.25±0.01[a]	ND
Palmitoleic	ND	0.24±0.03[a]	ND
Behenic	ND	ND	0.37±0.15[a]

[ab] Means with different superscripts along the row are significantly different ($p<0.05$)

Table 4.4: Internal attributes of eggs from broiler breeder hens fed varying dietary levels of supplemental vitamin E

Treatment (IU/kg)	Haugh Unit	Yolk height(cm)	Yolk diameter(cm)	Albumen weight(g)	Yolk weight(g)	Albumen height(cm)
0	69.32±15.42[b]	16.65±2.36	46.41±1.41	40.00±4.54	20.40±4.53	5.64±1.65[b]
20	80.82±4.59[ab]	18.13±1.18	44.52±1.01	36.20±3.70	20.80±1.30	6.79±0.71[ab]
40	82.71±4.71[a]	16.24±3.35	46.64±3.11	41.20±4.60	21.20±1.64	7.29±0.73[a]
60	83.97±3.55[a]	17.98±1.53	46.57±4.26	36.40±3.71	20.60±1.14	7.24±0.66[a]
80	77.3±11.3[ab]	16.91±1.10	45.35±6.41	38.20±3.27	21.60±2.07	6.54±1.41[ab]
100	80.9±3.5[ab]	16.69±2.32	46.56±2.87	37.40±5.03	20.80±2.77	6.83±0.53[ab]
SEM	1.67	0.38	0.63	0.77	0.30	0.20

[ab]Means with different superscripts down the column are significantly different ($p<0.05$) SEM: Standard error of mean

4.3 External attributes of eggs from broiler breeder hens fed varying dietary levels of supplemental vitamin E

The external attributes of egg from broiler breeder hens fed graded additions of tocopherol are presented in Table 4.5. None of the measured external parameters was affected ($p>0.05$) with the addition of supplemental α-tocopherol in the feed. However, it was observed that shell thickness ranged from 0.41±0.02 in the treatment supplemented with 80 IU/kg ($p>0.05$) to 0.35±0.07 in the treatment supplemented with 40 IU/kg.

The shell weight varied from 6.80±0.84 in treatments supplemented with 40 IU/kg and 60 IU/kg to 7.40±0.55 in treatments supplemented with 20 IU/kg and the treatment without any supplemental vitamin E. The egg weight ranged from 63.80±3.89 in the treatment supplemented with 60 IU/kg to 69.20±6.83 in the treatment supplemented with 40 IU/kg. Egg width also varied from 45.28±1.17 in the treatment supplemented with 60 IU/kg to 46.11±0.63 in the treatment supplemented with 20 IU/kg. Egg length ranged from 59.82±4.38 in 100 IU/kg to 61.34±3.36 in 40 IU/kg.

4.4 The α-tocopherol and total carotene deposition in the eggs of broiler breeder hens fed varying dietary levels supplemental vitamin E

The α-tocopherol and total carotene depositions in the eggs of broiler breeder hens fed graded dietary addition of supplemental vitamin E are shown in Table 4.6. The α-tocopherol composition of the eggs were expressly different ($p<0.05$) with the most α-tocopherol content observed in eggs of the treatments supplemented with 80 IU/kg (9.17±0.57) and 100 IU/kg (9.11±0.40) supplemental vitamin E. This was followed by those on the treatment supplemented with 60 IU/kg (8.62±0.51) supplemental vitamin E. However, treatments without vitamin E supplementation, 0 IU/kg (6.85±0.28) and treatments supplemented with 20 IU/kg (7.19±0.13) had the lowest content of α-tocopherol. There was no variation ($p>0.05$) in the total carotene component of the egg and it followed no trend.

Table 4.5: External attributes of eggs from broiler breeder hens fed varying levels of dietary supplement of vitamin E

TRT (IU/kg)	Shell thickness (mm)	Shell weight (g)	Egg weight (g)	Egg width (cm)	Egglength (cm)
0	0.39±0.02	7.40±0.55	67.40±4.51	45.89±1.51	59.93±3.28
20	0.37±0.02	7.40±0.55	64.40±3.21	46.11±0.63	60.12±1.89
40	0.35±0.07	6.80±0.84	69.20±6.83	46.02±1.34	61.34±3.36
60	0.37±0.04	6.80±0.84	63.80±3.89	45.28±1.17	61.21±3.26
80	0.41±0.02	7.20±0.84	67.00±4.85	45.85±1.68	60.54±1.56
100	0.39±0.05	7.00±1.00	65.20±7.01	45.56±1.34	59.82±4.38
SEM	0.01	0.14	0.23	0.53	0.94

Means with different superscripts along the column are significantly different ($p<0.05$): TRT; Treatment SEM; Standard error of mean

Table 4.6: The α-tocopherol and total carotene deposition in eggs of broiler breeder hens fed varying dietary inclusion levels of supplemental vitamin E

Parameter	0 IU	20 IU	40 IU	60 IU	80 IU	100 IU
α-tocopherol (mg/kg)	6.85±0.28^{c}	7.19±0.13^{c}	8.20±0.25^{b}	8.62±0.51^{ab}	9.17±0.57^{a}	9.11±0.40^{a}
Total carotene (mg/kg)	2.71±0.15	2.85±0.23	2.61±0.11	2.75±0.51	2.61±0.22	2.75±0.17

^{abc} Means with different superscripts along the row are significantly different ($p<0.05$) ; IU-International Unit

4.5 Relationship between supplemental vitamin E and α-tocopherol deposition in broiler breeder eggs

Figure 4.1 shows the relationship between the α-tocopherol concentration in the eggs of broiler breeder and the supplemental VE in the ration of broiler breeder hens. The relationship was quadratic, positive and significant ($p<0.05$). The regression curve shows that the optimum α-tocopherol concentration in the egg is 100 mg/kg. Although, a gradual increment in the α-tocopherol composition in the egg with increment in concentration of dietary α-tocopherol in the ration were observed, additional supplemental vitamin E in the ration above 100 IU/kg will lead to a decrease in composition of α-tocopherol in the eggs at a decreasing rate. The equation below explain the linear relationship between them

$$y = -0.000x^2 + 0.042x + 6.648 \qquad (R^2 = 0.927) \qquad \text{Equation 1}$$

The R^2 of 92.7% showed there was a strong positive relationship between α-tocopherol composition of the egg and supplemental dietary VE. Also, α-tocopherol was almost entirely dependent on dietary supplement of vitamin E.

4.6 Performance indices of broiler breeder hens fed varying dietary supplemental levels of vitamin E

Performance indices of Arbor acre plus hens offered variable dietary supplemental inclusions of vitamin E are highlighted in Table 4.7. Additional inclusion of vitamin E had no influence ($p<0.05$) on hen weight, egg weight and mortality but it affects hen day egg production (HDEP), egg mass and feed conversion ratio. Hen weight ranged from 3.98±0.49kg to 4.10±0.53kg, Egg weight was between 59.17±2.74g and 64.58± 5.27g while mortality ranged from 6.67±9.13 to 13.33±13.94. However, HDEP was noticeably greater ($p<0.05$) in treatments supplemented with 40 IU/kg (89.21±7.12) of dietary vitamin E while the lowest were in the treatments supplemented with 80 IU/kg (48.49±11.17) and 100 IU/kg (36.83±5.58). The treatments without vitamin E supplementation (61.75±6.56), 20 IU/kg (73.53±10.41) and 60 IU/kg (63.14±13.64) had no variation ($p<0.05$) in their HDEP.

The least egg mass ($p<0.05$) was reported in treatment supplemented with 100 IU/kg (22.38±3.52g) while those supplemented with 40 IU/kg (57.43±4.02) was the highest.

Treatments without vitamin E supplementation (36.50±3.82) as well as those on 60 IU/kg (37.59±6.69) and 80 IU/kg (30.47±6.96) were similar ($p<0.05$) in egg mass.

The best FCR among the group were obtained in birds on treatment supplemented with 40 IU/kg (2.92±0.20) while those on 100 IU/kg vitamin E inclusion had the poorest ($p<0.05$) FCR value of 7.62±1.24

Relationship between supplemental vitamin E and hen day egg production in broiler breeder hen

The relationship between supplementation of vitamin E and the HDEP of broiler breeder hens is shown in figure 4.2. The regression curve was significant ($p<0.05$), positive and quadratic. It increased at an increasing order up to an optimum point of 32 IU/kg. The equation below explained the quadratic relationship between them

$y = -0.0106x^2 + 0.7425x + 64.084$ $(R^2 = 0.6612)$ Equation 2

The R^2 showed that addition of tocopherol had a 66% influence on the hen day egg production. Other variations however have 34% influence on the outcome.

Relationship between supplemental vitamin E and feed conversion ratio of broiler breeder hen

The relationship between supplemental vitamin E and FCR of broiler breeder hens is shown in figure 4.3. The relationship is significant ($p<0.05$), quadratic and negative. The increased inclusion of vitamin E initially resulted in the reduction of the FCR to an optimum value of 32 IU/kg. The quadratic equation below represented the relationship:

$y = 0.001x^2 - 0.0651x + 4.5618$ $(R^2 = 0.7704)$ Equation 3

From the graph (figure 4.3) below, it can be deduced that 77% of the observed enhancement in the FCR of the broilers was due to the supplementation with vitamin E.

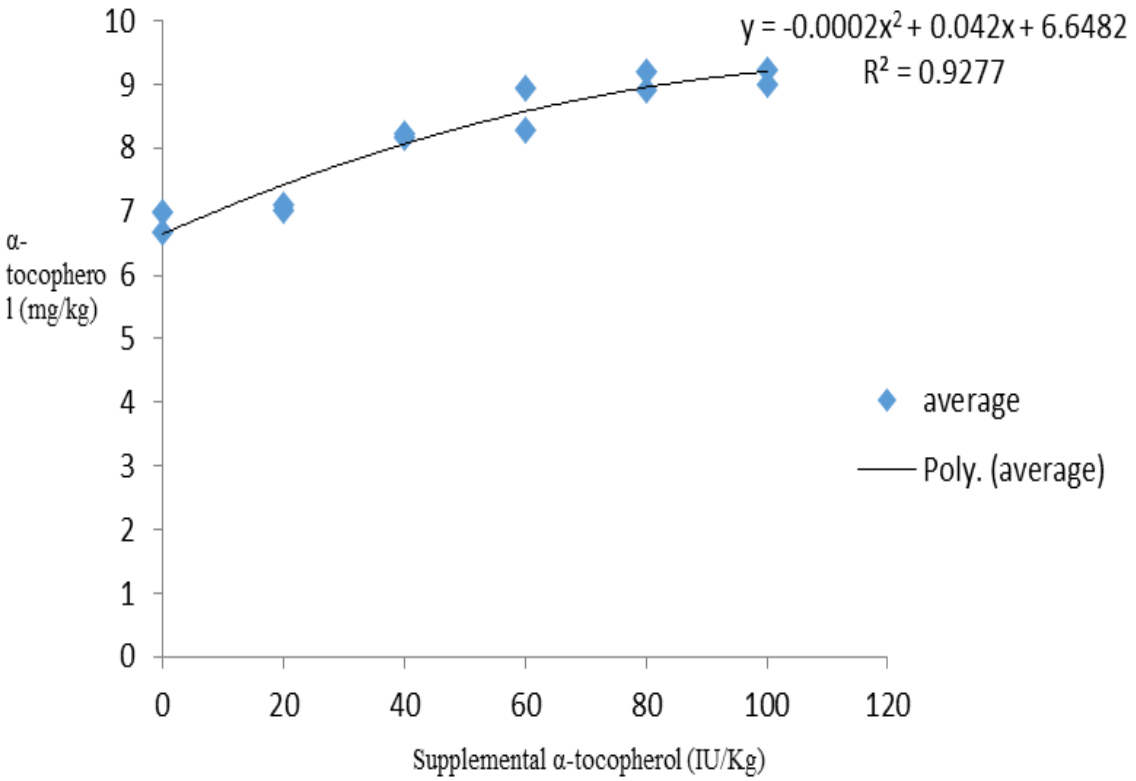


Figure 4.1: Relationship between supplemental vitamin E and α-tocopherol deposition in broiler breeder eggs

Table 4.7: Performance indices of broiler breeder hens fed varying levels of dietary supplement of vitamin E

Treatment (IU/kg)	Hen weight(kg)	HDEP %	Egg weight(g)	Egg mass(g)	Mortality	F C R
0	3.98±0.49	61.75±6.56^{b}	59.17±2.74	36.50±3.82^{c}	10.00±9.13	4.61±0.47^{bc}
20	4.09±0.43	73.53±10.41^{b}	60.90±3.14	44.70±5.92^{b}	6.67±9.13	3.79±0.47^{cd}
40	4.02±0.54	89.21±7.12^{a}	64.58±5.27	57.43±4.02^{a}	6.67±9.13	2.92±0.20^{d}
60	4.10±0.53	63.14±13.64^{b}	59.93±3.85	37.59±6.69^{c}	13.33±13.94	4.57±0.88^{bc}
80	4.00±0.48	48.49±11.17^{c}	62.96±4.91	30.47±6.96^{c}	13.33±13.94	5.68±1.11^{b}
100	4.03±0.50	36.83±5.58^{c}	60.75±2.79	22.38±3.52^{d}	10.00±9.13	7.62±1.24^{a}
SEM	0.08	3.49	0.73	2.23	1.89	0.31

^{abcd}Means with different superscripts along the same column are significantly different ($p<0.05$); HDEP-Hen day egg production; FCR Feed conversion ratio; g-grams; kg-kilogram.

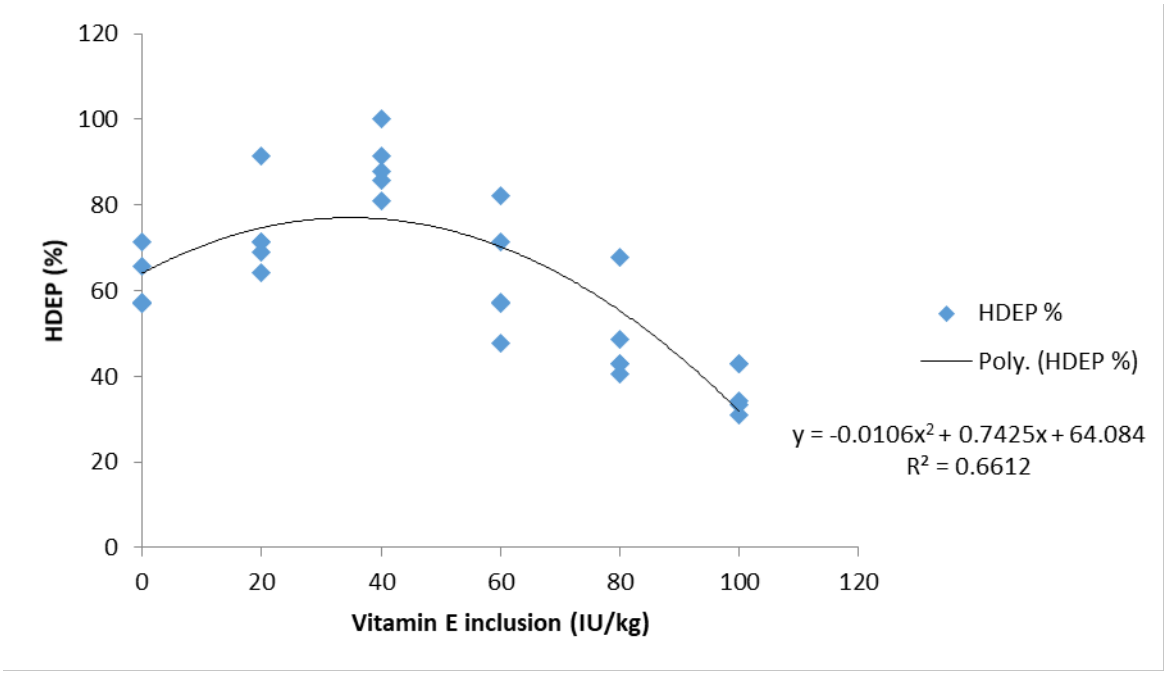


Figure 4.2: Relationship between supplemental vitamin E and hen day egg production in broiler breeder hen

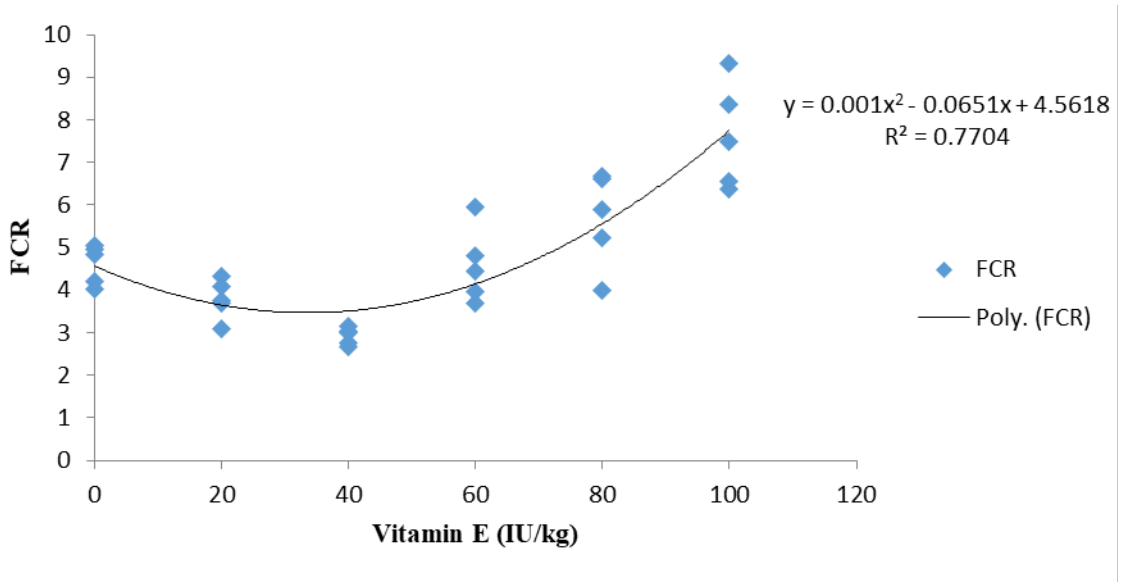


Figure 4.3: Relationship between supplemental vitamin E and feed conversion ratio of broiler breeder hen

4.7 Efficiency of production by broiler breeder hens fed varying dietary levels of supplemental vitamin E

The production efficiency of broiler breeder hen offered graded inclusion of dietary supplement of vitamin E is presented in Table 4.8. The most egg production ($p<0.05$) was observed at 40 IU/kg (34.97±0.89) which was noticeably greater ($p<0.05$) than in other dietary group. The treatment supplemented with 100 IU/kg (13.07±0.61) had the lowest ($p<0.05$) egg produced. The treatments supplemented with 60 IU/kg (22.97±1.42) and those without vitamin E supplementation, 0 IU/kg (22.23±1.11) were of similar ($p<0.05$) production.

The highest number of egg set ($p<0.05$) were attained in group fed ration containing 40 IU/kg (34.27±0.80) while those supplemented with 100 IU/kg (12.60±0.53) was the lowest ($p<0.05$). The treatment offered 60 IU/kg in diet (22.50±1.33) were similar ($p<0.05$) to those without vitamin E supplementation, 0 IU/kg (21.60±1.36). The egg transferred to the hatcher from the setter significantly varied ($p<0.05$) from the highest at 40 IU/kg (33.10±0.92) to the lowest at 100 IU/kg (11.43±0.25). The highest number of chicks per treatment ($p<0.05$) was obtained at 40 IU/kg (32.10±1.10) followed by 20 IU/kg (23.60±0.73).The number of chicks hatched in treatment with 60 IU/kg (19.50±1.30) was noticeably greater ($p<0.05$) relative to those hatched in treatment without any vitamin E supplementation, 0 IU/kg (18.10±0.92). The treatment supplemented with 100 IU/kg (9.9±0.10) had the lowest hatched chicks.

The fertility obtained in treatment supplemented with 40 IU/kg (96.57±0.80) was noticeably higher ($p<0.05$) comparable with other group. The lowest fertility ($p<0.05$) was obtained in the chicken without supplementation, 0 IU/kg (90.01±2.29) and those supplemented with 100 IU/kg (90.87±2.40) while those supplemented with 20 IU/kg (93.79±0.59) were similar ($p<0.05$) with those on 60 IU/kg (93.91±2.3) supplemental vitamin E.

The hatchability of eggs on the treatment supplemented with 40 IU/kg (96.95±1.50) was also significantly more ($p<0.05$) than in other treatments. However, the hatchability of those from other treatments were the same ($p>0.05$) except for the group offered ration containing 100 IU/kg (86.38±1.90) which had the lowest hatchability ($P<0.05$).

Table 4.8: Efficiency of production by broiler breeder hens fed varying levels of dietary supplement of vitamin E

Treatment (IU/kg)	Egg Produced	Egg set	Transfered	Hatched	Fertility %	Hatchability %
0	22.23+1.11^{c}	21.60+1.36^{c}	19.40+0.89^{d}	18.10+0.92^{d}	90.01+2.29^{c}	93.29+1.79^{b}
20	27.07+2.06^{b}	24.87+0.55^{b}	25.40+0.53^{b}	23.60+0.73^{b}	93.79+0.59^{b}	92.89+2.01^{b}
40	34.97+0.89^{a}	34.27+0.80^{a}	33.10+0.92^{a}	32.10+1.1^{a}	96.57+0.8^{a}	96.95+1.5^{a}
60	22.97+1.42^{c}	22.50+1.33^{c}	21.13+1.25^{c}	19.50+1.3^{c}	93.91+2.3^{b}	93.16+0.9^{b}
80	17.40+0.57^{d}	17.00+0.51^{d}	15.70+0.48^{e}	14.33+0.5^{e}	92.39+1.9^{bc}	91.24+1.7^{b}
100	13.07+0.61^{e}	12.60+0.53^{e}	11.43+0.25^{f}	9.90+0.1^{f}	90.87+2.4^{c}	86.38+1.9^{c}
SEM	0.95	0.88	0.54	0.79	0.81	0.58

^{abcd}Means with different superscripts along the same column are significantly different ($P<0.05$)

4.9 Relationship between egg fertility and dietary supplement of vitamin E

The relationship between egg fertility and dietary supplement of vitamin E is presented in Figure 4.3. The relationship was quadratic and optimum egg fertility was achieved at 55 IU/kg inclusion of α-tocopherol in the feed of broiler breeder hens. However, the increased inclusion of vitamin E in the diet resulted in decreased fertility of the eggs at a decreasing rate with the lowest observed with 100 IU/kg of supplemental vitamin E. The relationship is explained in equation 3 below;

$y = -0.0021x^2 + 0.2036x + 90.376$ $(R^2 = 0.5221)$ Equation 3

The R^2 of 52% shows that the supplemental vitamin E inclusion in the feed of the hens only influence the fertility of the eggs averagely. Other factors however had 48% chance of affecting fertility.

4.10 Relationship between egg hatchability and supplemental vitamin E

The relationship between egg hatchability and supplemental vitamin E is presented in figure 4.5. The relationship is quadratic, significant ($p<0.05$) and positive. The hatchability of the eggs ranged from 86.38% to 96.95% but the optimum hatchability of 94.80% was obtained at 37 IU/kg inclusion of vitamin E in the diet of broiler breeder hens. The relationship was represented by the equation below

$y = -0.0018x^2 + 0.1215x + 92.836$ $(R^2 = 0.6251)$

Equation 4

The equation above shows that 62% of the observed improvement in hatchability was due to supplemental α-tocopherol inclusion in the ration of broiler breeder hen

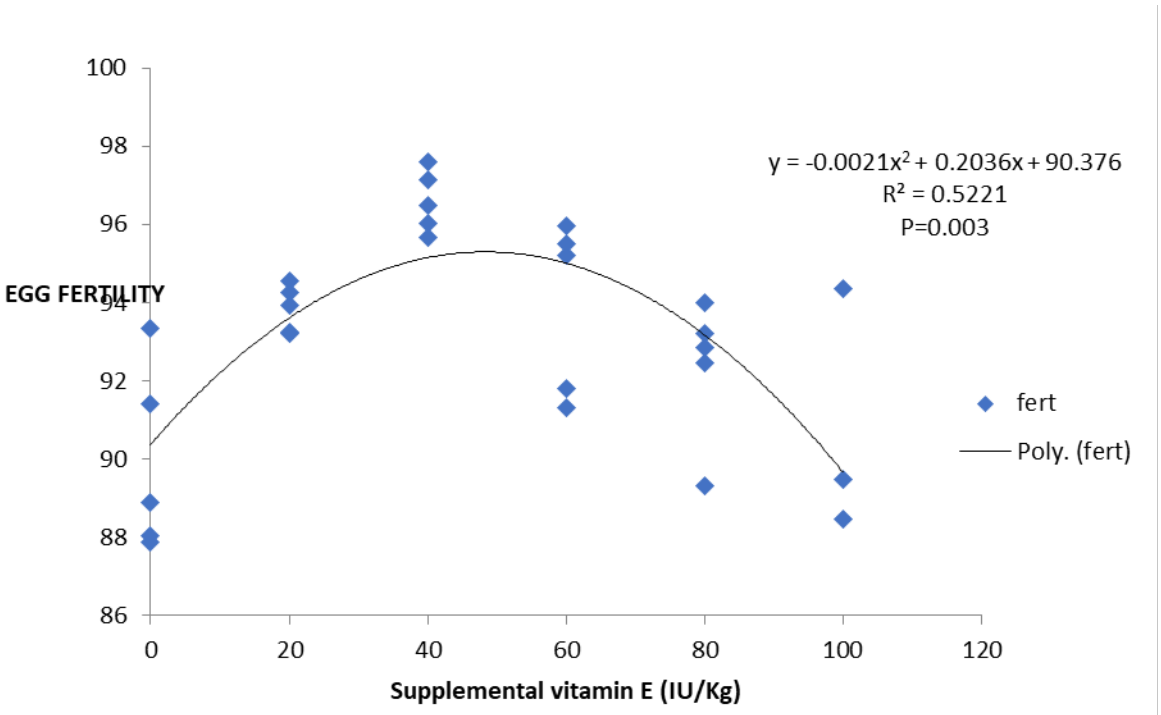


Figure 4.4: Relationship between egg fertility and supplemental vitamin E

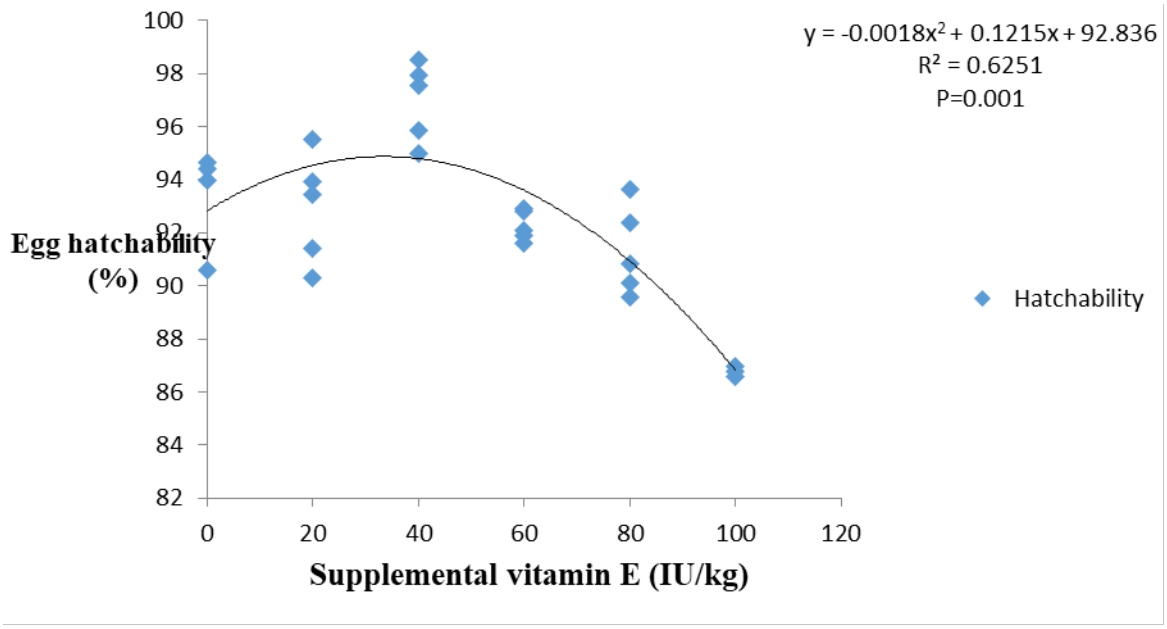


Figure 4.5: Relationship between egg hatchability and supplemental vitamin E

4.11 Effect of varying dietary levels of supplemental vitamin E on relative organ weights of hatched chicks

The effect of graded inclusions of supplemental α-tocopherol on relative organ weight of hatched chicks is as shown in Table 4.9. The chicks in treatment without supplemental vitamin E, 0 IU/kg (36.90±1.57) was expressively reduced ($p<0.05$) in body weight comparatively with other groups, while those with the highest chicks weight ($p<0.05$) were those supplemented with 40 IU/kg (42.93±1.30). All the chicks in other treatment group had similar ($p>0.05$) body weight.

The heart weight of the chicks in the treatment supplemented with 40 IU/kg (0.83±0.03) was expressively higher ($p<0.05$) comparatively with other groups while those in the treatment without vitamin E supplementation, 0 IU/kg (0.67±0.04) had the least heart weight which was followed by those supplemented with 20 IU/kg (0.72±0.04) supplemental vitamin E. The heart weight of the chicks in the treatment supplemented with 80 IU/kg (0.77±0.04) and 100 IU/kg (0.75±0.04) were similar ($p>0.05$).

The liver of the chicks in the treatment without any vitamin E supplementation, 0 IU/kg (2.72±0.10) and those supplemented with 20 IU/kg (2.69±0.1) were similar ($p>0.05$) and were both lower significantly ($p<0.05$) than the other treatment group. Those supplemented with 40 IU/kg (3.26±0.1), 60 IU/kg (3.12±0.1), 80 IU/kg (3.18±0.1) and 100 IU/kg (3.22±0.1) showed no significant variation ($p>0.05$). The relative weight of yolk sac of the various treatment group showed no remarkable variation ($p>0.05$). The value varied from 5.92±0.2 in 60 IU/kg supplemental vitamin E inclusion to 6.35±0.3 in the treatment without vitamin E supplementation.

4.12 Relationship between supplemental vitamin E and chicks weight

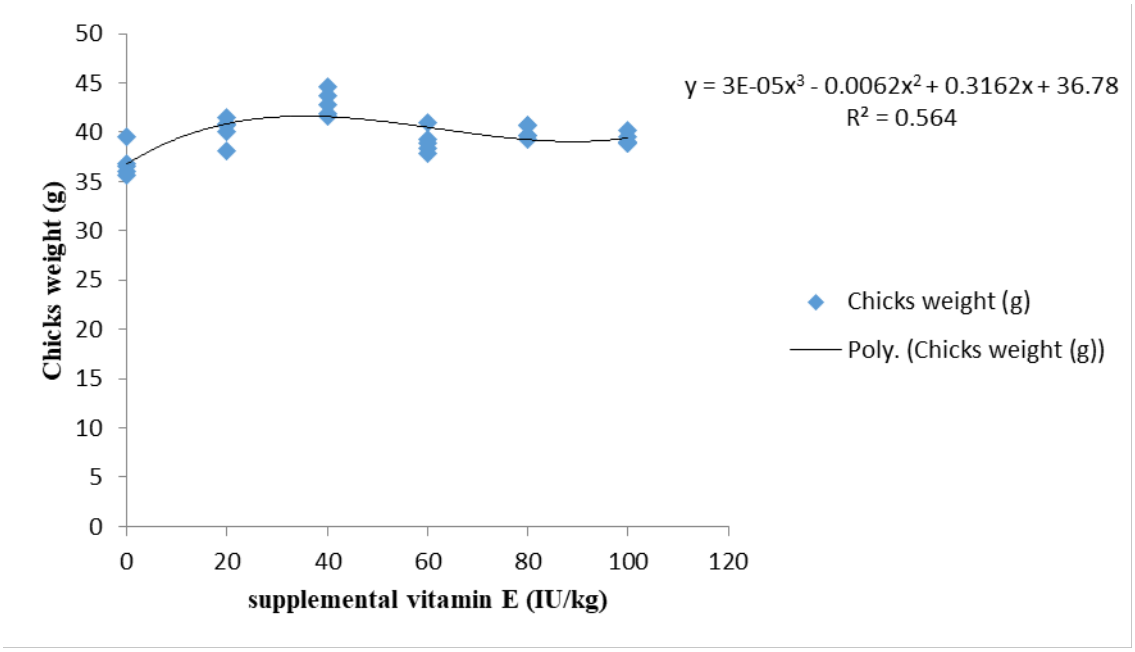
The relationship between supplemental vitamin E and body weight of hatched dayold chicks is presented in figure 4.6. The relationship is cubic, positive and significant ($p<0.05$). The best weight was obtained at an optimum value of 24 IU/kg of supplemental vitamin E. The relationship is presented in the equation below:

$y = 3E\text{-}05x^3 - 0.0062x^2 + 0.3162x + 36.78$ $R^2 = 0.564$ Equation 6

Table 4.9: Effect of varying levels of α-tocopherol on relative organ weights of hatched chicks

Treatment (IU/kg)	Chicks weight(g)	Heart	Liver	Yolk sac
0	36.90±1.57^{c}	0.67±0.04^{d}	2.72±0.1^{b}	6.35±0.3
20	40.23±1.3^{b}	0.72±0.04^{c}	2.69±0.1^{b}	6.30±0.5
40	42.93±1.3^{a}	0.83±0.03^{a}	3.26±0.1^{a}	6.17±0.4
60	39.07±1.2^{b}	0.78±0.05^{ab}	3.12±0.1^{a}	5.92±0.2
80	40.00±0.6^{b}	0.77±0.04^{bc}	3.18±0.1^{a}	6.21±0.1
100	39.27±0.6^{b}	0.75±0.04^{bc}	3.22±0.2^{a}	6.34±0.1
SEM	0.38	0.01	0.05	0.06

^{abc} Means with different superscripts along the column are significantly different (P<0.05)



Y-axis represent chicks weight; x-axis vitamin E inclusion

Fig 4.6: Relationship between supplemental vitamin E and chicks weight

4.13 Haematological indices of broiler breeder hens fed varying dietary supplemental levels of vitamin E

The haematological indices of Arbor acre plus hens fed graded dietary supplemental inclusion of vitamin E are shown in Table 4.10. The pack cell volume (PCV) in the treatment were similar ($p>0.05$) and their values varied from 26.8±2.2 to 30.4±1.5 in the treatment fed diets containing 40 IU/kg and 20 IU/kg supplemental vitamin E, respectively.

Haemoglobin concentration in the blood was significant ($p<0.05$) among the various treatment group with higher ($p<0.05$) haemoglobin values obtained at the treatment supplemented with 100 IU/kg (9.9±0.8) supplemental vitamin E. However, other treatment groups had similar ($p>0.05$) haemoglobin concentration. Higher red blood cell (RBC) count ($p<0.05$) was obtained in the samples of hens on 20 IU/kg (3.4±0.2), 60 IU/kg (3.5±0.2) and 100 IU/kg (3.4±0.1) supplemental vitamin E diet while those with 40 IU/kg (2.9±0.3) had lowest RBC ($p<0.05$). The group in 80 IU/kg (3.2±0.5) supplemental vitamin E and those without vitamin E supplementation, 0 IU/kg (3.2±0.4) had similar RBC count ($p>0.05$).

The white blood cell count (WBC) of the treatment not supplemented, 0 IU/kg (14720±2211.7) was the least ($p<0.05$) while those supplemented with 40 IU/kg (19440±1151.9), 60 IU/kg (19490±4479.2) and 100 IU/kg (19820±321.6) had the most ($p<0.05$) WBC. This may be owing to the inclusion of vitamin E which is an antioxidant in their diet.The lymphocytes were similar ($p>0.05$). However, the values fall between the lowest in 80 IU/kg (63.0±2.1) to the highest as observed in the treatment without vitamin E supplementation, 0 IU/kg (66.0±7.3). The heterophiles of the various treatment group were not varied significantly ($p>0.05$) but the values ranged from 26.6±6.8 in the treatment without vitamin E supplementation, 0 IU/kg to 30.2±7.3 and 30.2±1.6 in treatments containing 20 IU/kg and 80 IU/kg, respectively.

The monocytes which are the most prevalent white blood cells in the body was comparatively lower ($p<0.05$) in the treatment without vitamin E supplementation , 0 IU/kg (2.20±0.8) when compared to other treatment groups while the treatment

supplemented with 100 IU/kg (4.20±1.1) had the largest monocyte composition ($p<0.05$). Other group had similar ($p>0.05$) monocyte count.

Mean corpuscular volume (MCV) ranged from the highest value of 94.2±4.5 in 40 IU/kg to the lowest which was 86.9±8.9 in 60 IU/kg supplemental vitamin E inclusion and there was no significant variation among them ($p>0.05$) while the mean corpuscular haemoglobin concentration (MCHC) varied from the lowest ($p>0.05$) at 40 IU/kg (32.2±0.7) and 60 IU/kg (32.2±1.1) vitamin E inclusion to the highest at 0 IU/kg (32.7±0.8) and 20 IU/kg (32.7±0.9) supplemental vitamin E inclusion. The mean corpuscular haemoglobin (MCH) of the treatment group were similar ($p>0.05$). However, the values of MCH ranged from 30.4±1.7 (40 IU/kg) to 27.9±3.4 (60 IU/kg) vitamin E inclusion.

4.14: Serum indices of broiler breeder fed varying levels of dietary supplement of vitamin E

The serum indices of broiler breeder hens fed graded inclusions of α-tocopherol are presented in Table 4.11. Reduced glutathione (GSH) was substantially reduced ($p<0.05$) in the serum of hens in the treatment without vitamin E supplementation, 0 IU/kg (59.6±0.5) than in other treatment groups while the serum GSH of the chickens in the treatments supplemented with 20 IU/kg (60.6±1.1) and 40 IU/kg (60.2±0.4) were the same ($p>0.05$). The serum GSH of the chickens in the treatments supplemented with 60 IU/kg (61.3±1.6), 80 IU/kg (61.2±1.1) and 100 IU/kg (61.3±1.4) were noticeably greater ($p<0.05$) comparatively with other treatment group.

The catalase concentration in the serum of the chickens was significantly higher in the treatment supplemented with 100 IU/kg (722.17±186.9) while the least were obtained in the treatments not supplemented 0 IU/kg (560.52±51.2) and those supplemented with 20 IU/kg (551.75±245.8). The treatments supplemented with 40 IU/kg (684.43±60.9), 60 IU/kg (573.03±57.9) and 80 IU/kg (591.22±31.4) had similar ($p>0.05$) concentration of catalase.The superoxide dismutase (SOD) concentration in the serum was also significantly different. The treatment without vitamin E supplementation, 0 IU/kg (4.51±1.2) was noticeably lower ($p<0.05$) in SOD when compared to other treatment

group while the highest SOD concentration were observed at 80 IU/kg (7.39±2.0) and 100 IU/kg (7.14±2.1) dietary inclusion of supplemental vitamin E.

The alanine amino transferase (ALT) of the various treatment were similar ($p>0.05$). The values ranged from 24.4±12.6 recorded in the serum of chickens fed ration containing 80 IU/kg vitamin E inclusion to 31.4±4.0 in those without vitamin E supplementation i.e 0 IU/kg. Aspartate amino transferase (AST) were also not noticeably different ($p>0.05$) and the figures ranged from 189.0±7.1 to 194.0±4.8. The total cholesterol of the serum of the chickens were similar ($p>0.05$) and it varied from 210.6±62.8 to 225.4±41.5. The triglycerides also showed no variation ($p>0.05$) and it ranged from 138.1±49.2 in the serum of chicken fed diet containing 80 IU/kg supplemental vitamin E to 129.2±69.3 in those fed 40 IU/kg supplemental vitamin E.

4.15: The α-tocopherol and total carotene deposition in eggs of broiler breeder hens fed varying levels of shea butter and palm kernel oil

The α-tocopherol and total carotene deposition in eggs of breeder hens supplemented with graded levels of sheabutter (SB) and palm kernel oil (PKO) are obtainable in Table 4.12. The α-tocopherol deposition was considerably different ($p<0.05$) among the various treatment group. The eggs collected from the chickens in the treatments supplemented with 3% SB (8.00±0.4), 4.5% SB (8.09±0.9) and 0.0034%VE (7.95±0.2) had relatively higher ($p<0.05$) α-tocopherol composition than the remaining treatment group. This was followed by those in the treatment supplemented with 1.5% SB (7.56±0.3). The treatments without vitamin E supplementation, 0% (6.79±0.3), and those supplemented with 1.5% PKO (6.77±0.2), 3% PKO (6.84±0.6) and 4.5%PKO (6.80±0.1) had the lowest component of α-tocopherol in their eggs.

The total carotene deposition was also significantly higher ($p<0.05$) in the treatment with 4.5% SB (4.18±0.1) compared with other treatment group while those without supplementation, 0% (2.60±0.2), those supplemented with 0.0034% VE (2.7±0.1) and 1.5% PKO (2.66±0.1) had the lowest ($p<0.05$) total carotene depositions.

Table 4.10: Haematological indices of broiler breeder hens fed varying level of dietary supplement of vitamin E

Trt (IU/kg)	PCV (%)	Hb (gm/dl)	RBC (million/mL)	WBC (/mL)	Lym (/mL)	Het (/mL)	H/L ratio	Mono (/mL)	MCV (Fl)	MCHC (g/L)	MCH (Pg)
0	29.4±2.1	9.6±0.6^{ab}	3.2±0.4^{ab}	14720±2211.7^{b}	66.0±7.3	26.6±6.8	0.40±0.1	2.20±0.8^{b}	92.1±8.3	32.7±0.8	30.1±2.9
20	30.4±1.5	9.8±0.7^{ab}	3.4±0.2^{a}	16210±1938.6^{ab}	63.2±7.2	30.2±7.3	0.48±0.1	3.00±1.1^{ab}	88.9±1.8	32.7±0.9	29.1±1.3
40	26.8±2.2	8.6±0.7^{b}	2.9±0.3^{b}	19440±1151.9^{a}	63.6±5.5	29.2±5.8	0.46±0.1	3.00±1.0^{ab}	94.2±4.5	32.2±0.7	30.4±1.7
60	30.2±3.8	9.7±1.3^{ab}	3.5±0.2^{a}	19490±4479.2^{a}	64.8±9.1	27.4±9.5	0.42±0.2	3.40±1.5^{ab}	86.9±8.9	32.2±1.1	27.9±3.4
80	28.6±3.1	9.2±0.9^{ab}	3.2±0.5^{ab}	17470±4434.5^{ab}	63.0±2.1	30.2±1.6	0.48±0.1	2.80±1.1^{ab}	91.2±6.9	32.3±0.3	29.5±2.4
100	30.4±2.6	9.9±0.8^{a}	3.4±0.1^{a}	19820±321.6^{a}	63.2±6.7	29.4±6.7	0.47±0.1	4.20±1.1^{a}	88.9±6.1	32.4±0.6	28.6±1.7
SEM	0.51	0.20	0.19	634.50	1.13	1.14	0.16	0.27	1.24	0.11	0.47

^{ab}Means with different superscripts are significantly different (P<0.05) : PCV; Pack cell volume: Hb; haemoglobin: RBC; Red blood cell: WBC; white blood cell : Lym; lymphocytes: Het; heterophils: H/L ;heterophils to lymphocytes ratio:Mono; monocytes: MCV; mean corpuscular volume: MCHC; mean corpuscular haemoglobin concentration: MCH: mean corpuscular haemoglobin

Table 4.11: Serum indices of broiler breeder fed varying levels of dietary supplement of vitamin E

Treatment (IU/kg)	GSH (mu/mg)	Catalase (u/ml)	SOD (u/mg)	ALT (iu/l)	AST (iu/l)	Cholesterol	Triglycerides
0	59.6±0.5^{b}	560.52±51.2^{b}	4.51±1.2^{c}	31.4±4.0	190.2±4.4	210.6±62.8	135.1±35.9
20	60.6±1.1^{ab}	551.75±245.8^{b}	5.49±0.9^{bc}	30.0±8.8	189.2±6.0	222.4±23.7	130.7±33.7
40	60.2±0.4^{ab}	684.43±60.9^{ab}	6.75±0.5^{ab}	29.0±6.2	189.0±7.1	225.4±41.5	129.2±69.3
60	61.3±1.6^{a}	573.03±57.9^{ab}	6.12±0.9^{ab}	28.4±9.4	194.0±4.8	218.4±63.0	132.9±29.1
80	61.2±1.1^{a}	591.22±31.4^{ab}	7.39±2.0^{a}	24.4±12.6	192.8±0.5	215.8±45.6	138.1±49.2
100	61.3±1.4^{a}	722.17±186.9^{a}	7.14±2.1^{a}	27.2±10.8	193.2±5.8	220.8±44.1	136.8±30.5
SEM	0.19	21.67	0.22	1.6	0.9	10.2	15.7

^{abc} Means with different superscripts are significantly different (P<0.05) : SOD; superoxide dismutase :GSH; Reduced glutathione: ALT; Alanine transferase: AST; Aspatate transferase

Table 4.12: α-tocopherol and total carotene deposition in eggs of broiler breeder hens fed varying levels of sheabutter and palm kernel oil

PARAMETER	0%	0.034%VE	1.5% PKO	3% PKO	4.5% PKO	1.5% SB	3% SB	4.5% SB
α-tocopherol (mg/kg)	6.79±0.3^{b}	7.95±0.2^{a}	6.77±0.2^{b}	6.84±0.6^{b}	6.80±0.1^{b}	7.56±0.3^{ab}	8.00±0.4^{a}	8.09±0.9^{a}
Totalcarotene (mg/kg)	2.60±0.2^{c}	2.70±0.1^{c}	2.66±0.1^{c}	3.00±0.4^{b}	2.98±0.1^{b}	3.42±0.2^{ab}	3.61±0.8^{ab}	4.18±0.1^{a}

^{abc} Means with different superscripts along the row are significantly different (P<0.05) ; PKO-Palm kernel oil; SB-Shea butter; VE- Vitamin E

4.16: Performance indices of broiler breeder hens fed varying dietary levels of shea butter and palm kernel oil

The performance indices of Arbor acre plus hens supplemented with graded inclusions of sheabutter and palm kernel oil are highlighted in Table 4.13. There was no variation ($p>0.05$) in the weight of the hens and values ranged from 4.29±0.5 in the treatment without supplementation, 0% to 4.64±0.2 in those supplemented with 0.0034%VE. HDEP was significantly lower ($p<0.05$) in the treatment without supplementation, 0% (54.12±5.1) and those supplemented with 4.5% PKO (52.73±8.5) than in other treatment groups while it was substantial ($p>0.05$) in hens on feed containing 0.0034% VE (69.12±5.6), 1.5% SB (65.44±8.5), 3% SB (70.79±8.5) and 4.5% SB (68.29±8.0).

The egg weights were also significantly varied ($p<0.05$) with those from the hens offered 0.0034% supplemental VE (73.48±4.1) having higher ($p<0.05$) egg weights while those treatment supplemented with 1.5% PKO (64.05±2.9) had the lowest ($p<0.05$) egg weight. The treatments without supplementation , 0% (66.69±5.1), those supplemented with 3% PKO (65.39±2.4) and 4.5% PKO (65.75±4.5) all had similar ($p>0.05$) egg weight.The treatments supplemented with 3% SB (50.29±7.1), 4.5% SB (48.52±9.2) and 0.0034% VE (50.87±5.9) were noticeably higher ($p<0.05$) in egg mass than the other group while the treatment without supplementation, 0% (36.16±5.1) and those supplemented with 4.5% PKO (34.68±3.4) had the lowest ($p<0.05$) egg mass. The egg mass of the treatments supplemented with 1.5% PKO (37.89±6.5) and 3% PKO (39.08±6.4) were similar ($p>0.05$).

There was no variation ($p>0.05$) in mortality of the various treatment groups and the values ranged from no mortality in the hens of the treatment supplemented with 4.5% SB to 16.00±16.7 in the treatments supplemented with 0.0034% VE, 1.5% PKO and 3% PKO. The treatments with the better feed conversion ratio (FCR) were observed at 0.0034% VE (3.18±0.4), 3% SB (3.24±0.5) and 4.5% SB (3.39±0.6) and they were substantially lower ($p<0.05$) than the remaining treatment group while the treatment without supplementation, 0% (4.49±0.6) and those supplemented with 1.5% PKO (4.33±0.8) and 4.5% PKO (4.65±0.5) had the highest FCR

Table 4.13: Performance indices of broiler breeder hens fed diets supplemented with varying levels of shea butter and palm kernel oil

Treatment	Hen weight (kg)	HDEP %	egg weight (g)	Egg mass (g)	Mortality (%)	F C R
0 %	4.29±0.5	54.12±5.1^{b}	66.69±5.1^{bc}	36.16±5.1^{c}	4.00±8.9	4.49±0.6^{a}
0.0034%VE	4.64±0.2	69.12±5.6^{a}	73.48±4.1^{a}	50.87±5.9^{a}	16.00±16.7	3.18±0.4^{c}
1.5% PKO	4.31±0.6	59.37±11.5^{ab}	64.05±2.9^{c}	37.89±6.5^{bc}	16.00±16.7	4.33±0.8^{a}
3% PKO	4.49±0.5	59.87±10.3^{ab}	65.39±2.4^{bc}	39.08±6.4^{bc}	16.00±16.7	4.19±0.7^{ab}
4.5% PKO	4.36±0.4	52.73±8.5^{b}	65.75±4.5^{bc}	34.68±3.4^{c}	12.00±10.9	4.65±0.5^{a}
1.5% SB	4.43±0.4	65.44±8.5^{a}	70.49±6.8^{abc}	45.76±3.2^{ab}	12.00±17.9	3.51±0.2^{bc}
3% SB	4.31±0.4	70.79±8.5^{a}	70.91±2.4^{ab}	50.29±7.1^{a}	8.00±17.9	3.24±0.5^{c}
4.5% SB	4.53±0.6	68.29±8.0^{a}	70.64±5.8^{ab}	48.52±9.2^{a}	0.00±0.00	3.39±0.6^{c}
SEM	0.01	1.55	0.82	1.33	2.26	0.12

^{abc}Means with different superscripts along the column are significantly different (P<0.05). HDP-Hen Day Egg Production; FCR-Feed Conversion Ratio; PKO-Palm kernel oil; SB-Sheabutter; VE- vitamin E

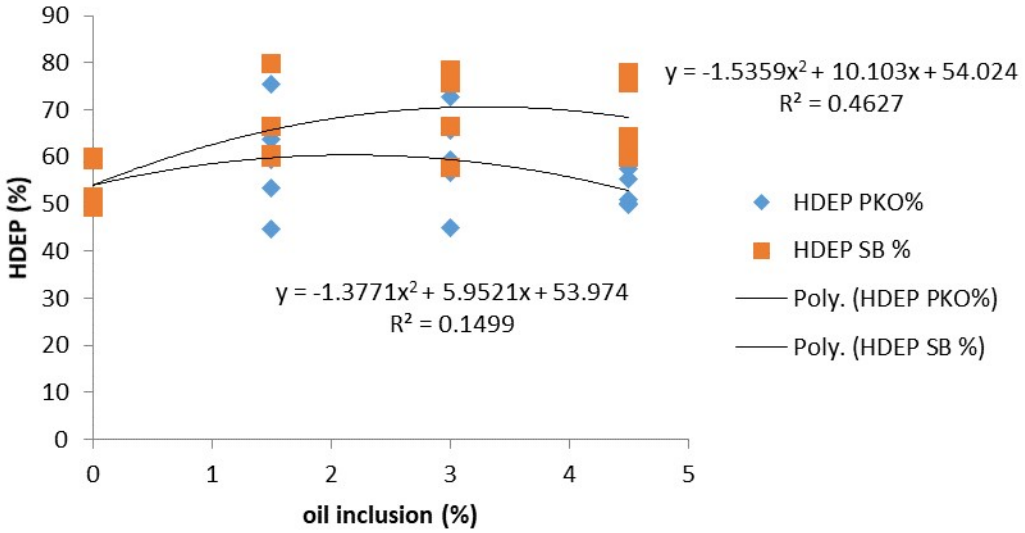


Figure 4.7: Relationship between supplemental palm kernel oil/shea butter and hen day egg production of broiler breeder hens

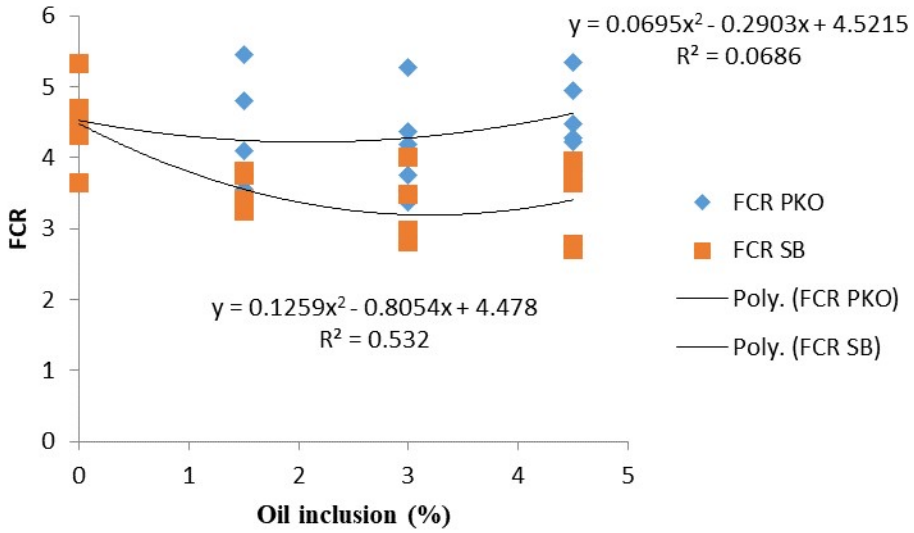


Figure 4.8: Relationship between supplemental palm kernel oil/shea butter and feed conversion ratio of broiler breeder hens

4.17 Relationship between supplemental palm kernel oil/shea butter and hen day egg production of broiler breeder hens

The relationship between supplemental PKO/SB and HDEP of broiler breeder hens is shown in figure 4.7. Both relationships were significant ($p<0.05$), quadratic and positive. The equations below represent the relationship between hen day egg production and PKO/SB respectively:

$y = -1.3771x^2 + 5.9521x + 53.974$ ($R^2 = 0.1499$) Equation 7

$y = -1.5359x^2 + 10.103x + 54.024$ ($R^2 = 0.4627$) Equation 8

The optimum inclusion level of PKO was 1.2% while SB had an optimum level of 2% inclusion and the higher R^2 observed in SB showed that SB had more influence on the improved hen day egg production than what was observed in PKO

4.18 Relationship between supplemental palm kernel oil/shea butter and feed conversion ratio of broiler breeder hens

Relationship between supplemental palm kernel oil/shea butter and FCR of broiler breeder hens is shown in fig 4.8. Both relationships are quadratic, negative and significant ($p<0.05$). The addition of the oils caused a reduction in FCR. However, while the optimum inclusion of PKO was at 1.5% inclusion, SB had an optimum inclusion of up to 3%. The equations below represent the relationships between FCR and PKO/SB respectively:

$y = 0.0695x^2 - 0.2903x + 4.5215$ ($R^2 = 0.0686$) Equation 9

$y = 0.1259x^2 - 0.8054x + 4.478$ ($R^2 = 0.532$) Equation 10

4.19 Breeding efficiency of broiler hens fed diets supplemented with varying levels of shea butter and palm kernel oil

The breeding efficiency of Arbor Acres plus hens enhanced with varying quantities of sheabutter and PKO are presented in Table 4.14. The 31.30±0.6 in 3% SB weekly egg produced were significantly higher ($p<0.05$) than in other treatment group while the treatment without supplementation, 0% (17.73±1.1) and those supplemented with 1.5% PKO (17.67±1.4) had the least ($p<0.05$) egg production. The treatments supplemented with 0.0034% VE (29.50±0.8) were similar ($p>0.05$) to those supplemented with 4.5% SB (29.53±0.70). The same trend was observed for the treatment supplemented with 3% PKO (22.03±1.3) and 4.5% PKO (23.13±0.4).

The egg set in the treatment without supplementation, 0% (17.23±1.1) and those supplemented with 1.5% PKO (17.50±1.5) were significantly lower ($p<0.05$) relative to other treatment group while the greatest ($p<0.05$) quantity of settable eggs were obtained in the treatment supplemented with 3% SB (31.17±0.6) and it is significantly higher ($p<0.05$) than other treatment group. This was followed by the treatment supplemented with 4.5% SB (29.40±0.6).The treatment supplemented with 3% SB (29.77±0.5) had the greatest ($p<0.05$) quantity of eggs transferred into the hatcher from the incubator which was followed by the treatments supplemented with 0.0034% VE (27.97±0.8) and 4.5% SB (27.77±0.3). The treatments without supplementation, 0% (14.33±1.0) and those supplemented with 1.5% PKO (14.40±1.3) had the least ($p<0.05$) egg transferred.

The most ($p<0.05$) hatched chicks were obtained from the hens offered feed containing 3% SB (28.53±0.7) while the lowest were obtained from those without supplementation, 0% (12.37±1.3) and those supplemented with 1.5% PKO (12.27±1.0). The treatments supplemented with 4.5% SB (26.47±0.3) and 0.0034%VE (26.90±0.9) had similar ($p<0.05$) hatched chicks number. Highest fertility ($p<0.05$) was obtained from hens in the treatments fed ration supplemented with 0.0034% VE (95.23±1.2), 3% SB (95.50±1.1) and 4.5% SB (94.39±1.4) while the treatments without supplementation, 0% (82.97±2.3) and those supplemented with 1.5% PKO (82.35±2.6) had the lowest ($p<0.05$) fertility. The treatments without supplementation, 0% (85.98±4.1) and those supplemented with 1.5% PKO (85.23±1.4) had a considerably lower ($p<0.05$) hatchability relative to other treatment group while the hatchability obtained from eggs laid by hens on feed containing 3% SB (95.83±1.1) and 0.0034% VE (96.19±0.5) were highest ($p<0.05$).

Table 4.14: Breeding efficiency of broiler hens fed varying levels of shea butter and palm kernel oil

Treatment	Egg Produced	Egg set	Transfered	Hatched	Fertility %	Hatchability %
0 %	17.73±1.1^{e}	17.23±1.1^{f}	14.33±1.0^{e}	12.37±1.3^{f}	82.97±2.3^{d}	85.98±4.1^{e}
0.0034% VE	29.50±0.8^{b}	27.37±0.6^{c}	27.97±0.8^{b}	26.90±0.9^{b}	95.23±1.2^{a}	96.19±0.5^{a}
1.5 % PKO	17.67±1.4^{e}	17.50±1.5^{f}	14.40±1.3^{e}	12.27±1.0^{f}	82.35±2.6^{d}	85.23±1.4^{e}
3% PKO	22.03±1.3^{d}	21.80±1.2^{e}	19.17±1.2^{d}	17.17±1.0^{e}	87.98±0.8^{c}	89.55±0.8^{d}
4.5% PKO	23.13±0.4^{d}	22.93±0.4^{e}	20.23±0.7^{d}	18.57±0.6^{d}	88.11±2.1^{c}	91.86±0.8^{c}
1.5 % SBO	25.23±0.5^{c}	25.00±0.4^{d}	22.63±0.4^{c}	21.07±0.5^{c}	90.67±1.7^{b}	92.94±1.4^{bc}
3 % SBO	31.30±0.6^{a}	31.17±0.6^{a}	29.77±0.5^{a}	28.53±0.7^{a}	95.50±1.1^{a}	95.83±1.1^{a}
4.5 % SBO	29.53±0.7^{b}	29.40±0.6^{b}	27.77±0.3^{b}	26.47±0.3^{b}	94.39±1.4^{a}	94.54±0.9^{ab}
SEM	0.81	0.78	0.92	0.97	0.82	0.68

^{abcdef}Means with different superscripts along the column are significantly different ($P<0.05$). PKO-Palm kernel oil; SB-Shea butter; VE-Vitamin E

4.20 Relationship between fertility/hatchability and palm kernel oil

The relationship between egg hatchability and varying dietary supplemental levels of PKO is shown in Figure 4.6. The relationship is quadratic and positive and the regression showed that the optimum hatchability of 91.86% was obtained at 4.5% inclusion of PKO and any additional inclusion will only result in a decline in hatchability. The equation 5 below represents the relationship with an R^2 value of 89% which indicated that there was a strong and positive relationship which showed that the hatchability was highly dependent on the palm kernel oil inclusion in the diet.

$y = -0.476x^2 + 5.039x + 78.74$ $(R^2 = 0.897)$ Equation 11

Figure 4.7 showed the relationship between egg fertility and varying dietary supplemental levels of palm kernel oil. The relationship was quadratic and positive.The regression showed that the optimum fertility of 89% was obtained at 4% inclusion in the diet. However, the continued addition of PKO in the feed led to the decrease in fertility. The R^2 showed that the fertility was 74% dependent PKO inclusion in the ration. The equation 6 below represents the relationship:

$y = -1.179x^2 + 9.055x + 71.34$ $(R^2 = 0.741)$ Equation 12

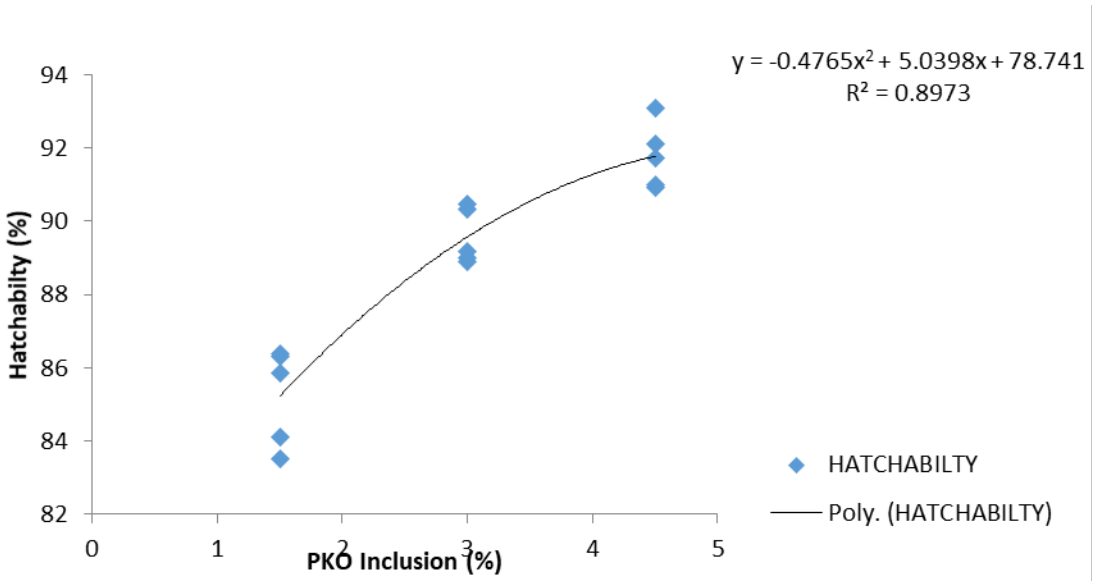


Figure 4.9: Relationship between egg hatchability and supplemental palm kernel oil

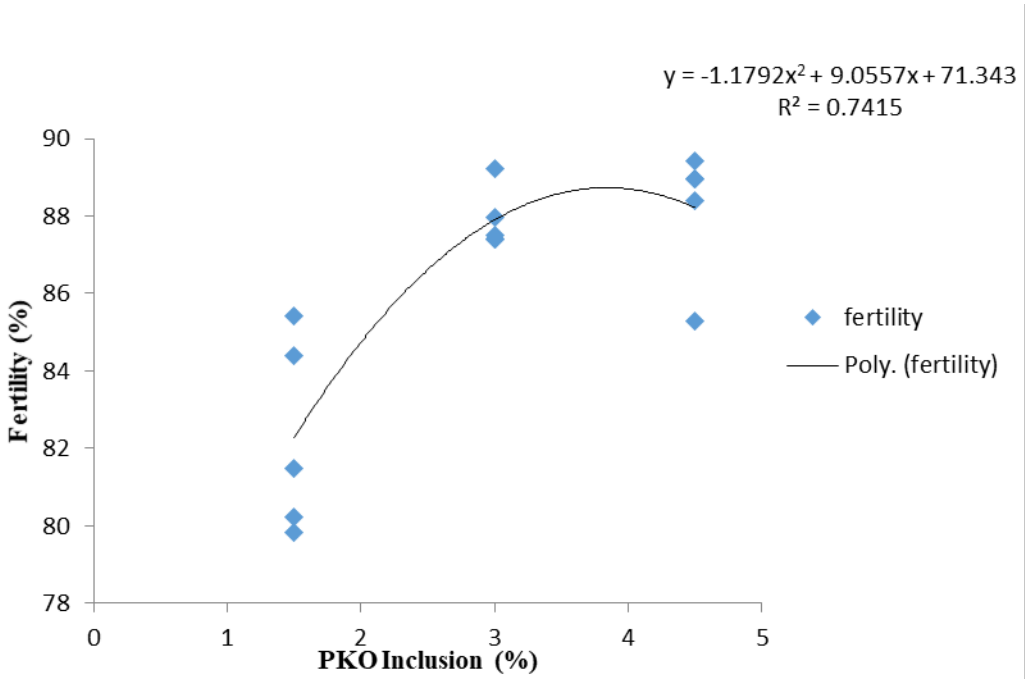


Figure 4.10: Relationship between egg fertility and supplemental palm kernel oil

4.21 Relationship between egg fertility/hatchability and supplemental shea butter

The relationship between egg fertility and supplemental shea butter are presented in Figure 4.7. The relationship was quadratic and positive. The optimum fertility of 95.60% was achieved at 3.2% inclusion of shea butter in the diet after which further inclusion of the shea butter brought about a rise in fertility of the eggs at a decreasing rate. However, at 3.5% of shea butter inclusion, fertility began to decrease from 95.80% to 94.39% at 4.5% shea butter inclusion. The equation 7 below expressed the relationship:

$y = -1.341x^2 + 9.351x + 79.53$ ($R^2 = 0.745$) Equation 13

Figure 4.9 shows the relationship between egg hatchability and supplemental shea butter. The relationship was quadratic and positive. The optimum hatchability of 96.00% was achieved at 3.2% inclusion of shea butter. However, the optimum was maintained up to 3.6% shea butter inclusion before declining to 95.20% at 4.5% inclusion. The contribution of shea butter to the hatchability of the eggs was 58% while other factors such as the conditions of the hatching machine and so on contributed 42%. The equation below represented the relationship:

$y = -0.730x^2 + 5.130x + 87.03$ ($R^2 = 0.580$) Equation 14

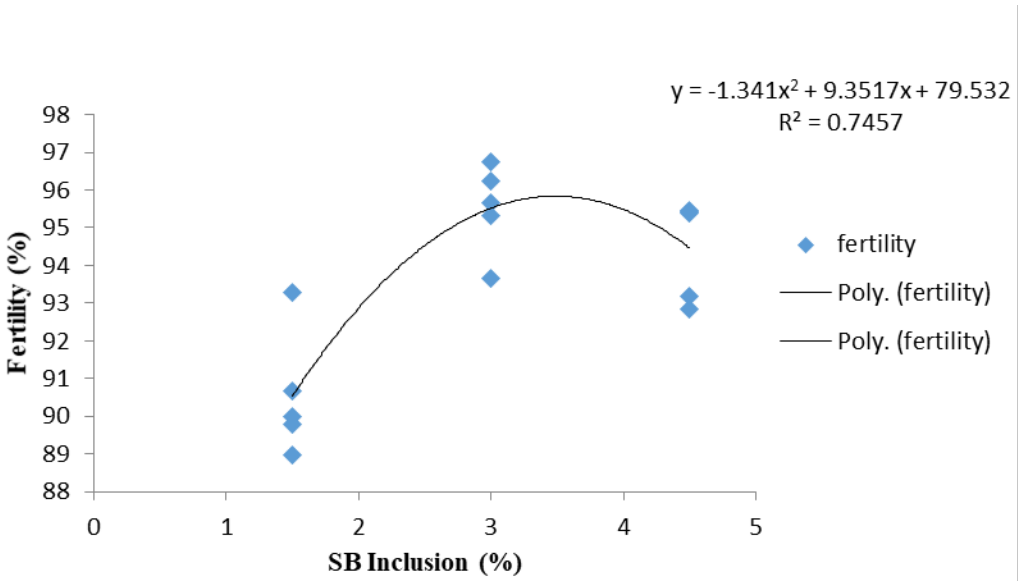


Figure 4.11: Relationship between egg fertility and supplemental sheabutter

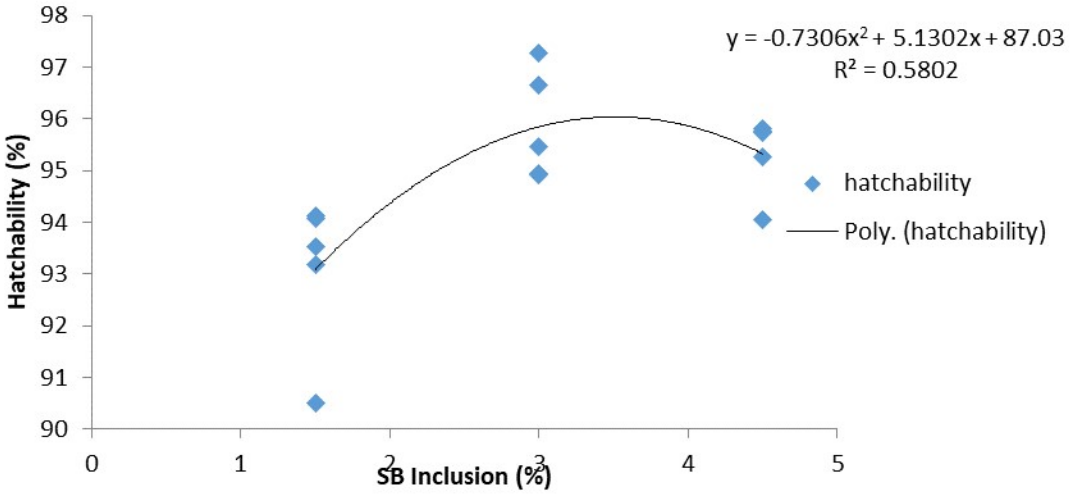


Figure 4.12: Relationship between egg hatchability and supplemental shea butter

4.22 Effects of shea butter and palm kernel oil on relative organ weights of hatched chicks

The relative effect of SB and PKO on the weight of the organs of hatched chicks is illustrated in Table 4.15. The weight of chicks from hens fed ration containing 0.0034%VE (48.93±0.76) was substantially lower ($p<0.05$) relative to those on 3% SB (51.40±1.34) but higher considerably ($p<0.05$) than the remaining dietary group. However, the treatment without supplementation, 0% (39.87±1.21), those supplemented with 1.5% PKO (39.73±2.76), 3% PKO (40.07±1.57), 4.5% PKO (42.27±2.43) and 1.5% SB (40.67±1.03) had similar ($p<0.05$) chicks weight.

The heart of hatched chicks from hens fed rations containing 0.0034% VE (0.81±0.02), 3% SB (0.81±0.01) and 4.5% SB (0.79±0.01) were noticeably higher ($p<0.05$) relative to the other dietary groups while those without supplementation, 0% (0.65±0.01) had considerably lower ($p<0.05$) relative heart weight comparable with the remaining treatment group. However, those containing 1.5% PKO (0.70±0.02) and 3% PKO (0.70±0.04) had similar ($p<0.05$) heart weight. The liver of chicks produced by hens fed diets without supplementation, 0% (2.73±0.29), those supplemented with 1.5% PKO (2.73±0.11) and 3% PKO (2.77±0.21) were substantially reduced ($p<0.05$) compared with other treatment group while those in the treatment supplemented with 0.0034% VE (3.19±0.29) had the biggest liver. The liver of the treatment supplemented with 1.5% SB (3.06±0.20), 3% SB (3.12±0.15) and 4.5% SB (3.12±0.18) were similar ($p>0.05$)

The yolk sac of the various treatment group were similar ($p>0.05$) and it ranged from 6.67±0.44 in the treatment without supplementation, 0% to 6.27±0.17 in those supplemented with 3% PKO.

4.23 Relationship between supplemental palm kernel oil/shea butter and chicks weight

The relationship between supplemental PKO/SB and chicks weight are shown in figure 13.The relationships are linear, positive and significant ($p<0.05$). They both increase at an increasing rate and the relationships between chicks weight and PKO/SB are illustrated using the equations respectively:

$y = 0.5022x + 39.353$ $(R^2 = 0.1552)$ Equation 15

$y = 2.4356x + 39.62$ $(R^2 = 0.6121)$ Equation 16

Table 4.15: Effects of shea butter and palm kernel oil on relative organ weights of hatched chicks

Treatment	Weight (grams)	Heart	Liver	Yolk sac
0%	39.87±1.21^{c}	0.65±0.01^{d}	2.73±0.29^{c}	6.67±0.44
0.0034%VE	48.93±0.76^{ab}	0.81±0.02^{a}	3.19±0.29^{a}	6.53±0.25
1.5%PKO	39.73±2.76^{c}	0.70±0.02^{c}	2.73±0.11^{c}	6.44±0.22
3%PKO	40.07±1.57^{c}	0.70±0.04^{c}	2.77±0.21^{c}	6.27±0.17
4.5%PKO	42.27±2.43^{c}	0.73±0.04^{bc}	2.86±0.17^{bc}	6.53±0.26
1.5%SB	40.67±1.03^{c}	0.75±0.05^{b}	3.06±0.20^{ab}	6.39±0.21
3%SB	51.40±1.34^{a}	0.81±0.01^{a}	3.12±0.15^{ab}	6.43±0.37
4.5%SB	48.47±3.06^{b}	0.79±0.01^{a}	3.12±0.18^{ab}	6.50±0.23
SEM	0.78	0.01	0.04	0.04

^{abc} Means with different superscripts along the column are significantly different (P<0.05): PKO-Palm kernel oil; SB-Sheabutter

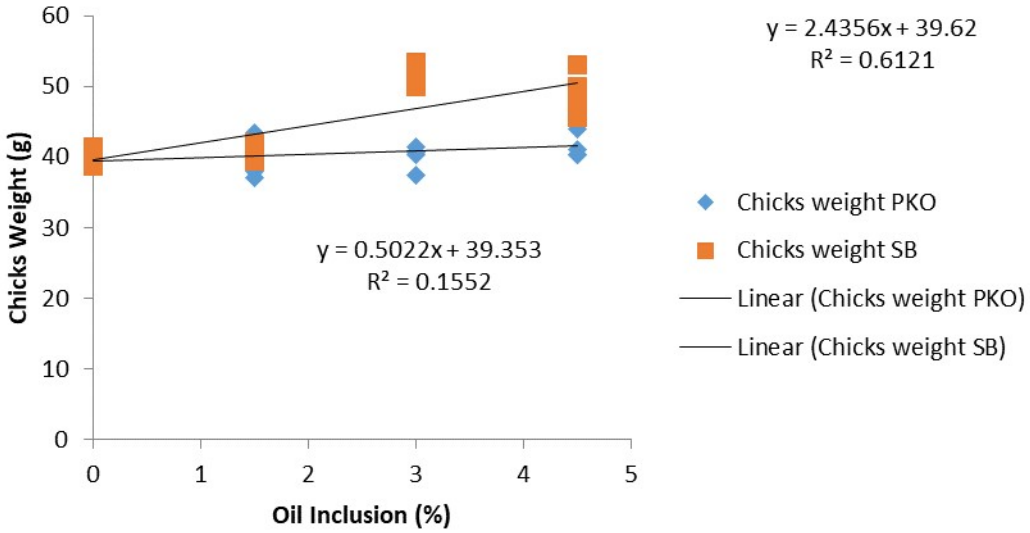


Figure 4.13: Relationship between supplemental palm kernel oil/sheabutter and chicks weight

4.24 Haematological indices of broiler breeder hens fed varying dietary inclusion of shea butter and palm kernel oil

The haematological indices of broiler breeder hens offered ration containing dietary levels of inclusion of SB and PKO are shown in Table 4.16. The pack cell volume (PCV) differed expressively ($p<0.05$) with the blood of hens on 3% PKO (39.60±1.5) and 4.5% SB (38.40±4.4) having substantially higher ($p<0.05$) PCV relative to other treatment group. However, those fed diets supplemented with 1.5% PKO (30.20±3.8), 1.5% SB (30.40±2.3) and 3% SB (28.6±3.9) are similar ($p<0.05$). Those supplemented with 4.5% PKO (37.00±3.5) had a substantially greater ($p<0.05$) PCV than those than supplemented with 1.5% SB (30.40±2.3), 3% SB (28.6±3.9) and 1.5% PKO (30.20±3.8) but lower than those supplemented with 3% PKO (39.60±1.5) and 4.5% SB (38.40±4.4).

The haemoglobin concentration in the blood of hens fed diet without supplementation, 0% (8.21±0.9) was comparatively lower ($p<0.05$) than other treatment group. Those fed diets supplemented with 0.0034% VE (9.71±0.6), 1.5% PKO (9.73±0.6), 3% PKO (9.42±0.5) and 1.5% SB (9.60±0.7) had the same ($p>0.05$) haemoglobin concentration but the hens on ration supplemented with 4.5% PKO (10.60±1.5), 3% SB (10.62±0.6) and 4.5% SB (10.80±1.9) had a substantially greater ($P<0.05$) haemoglobin relative to other treatment group.

The red blood cell count were not substantially different ($p>0.05$) although the values fall between 3.19±0.3 in those supplemented with 4.5% PKO to 3.27±0.4 in those offered ration containing 4.5% SB. The white blood cell count was remarkably lower ($p<0.05$) in those without supplementation, 0% (14640±2122.7), those supplemented with 1.5% PKO (14820±1279.1) and 3% PKO (14780±2239.6) than the other treatment group while a remarkable difference was obtained ($p<0.05$) in those supplemented with 0.0034% VE (19470±4009.2), 3% SB (18920±3955.4) and 4.5% SB (19290±4972.7).

The lymphocytes, heterophils, monocytes, MCV, MCHC and MCH were all similar ($p>0.05$) amongst the treatments. The lymphocytes fluctuated from 66.00±4.9 in those supplemented with 1.5% PKO to 62.80±7.9 in those supplemented with 4.5% PKO. Heterophils ranged from

30.40±5.8 in those supplemented with 1.5% PKO to 27.40±4.9 in those supplemented with 0.0034%VE.

Monocytes varied from 2.84±0.2 in those supplemented with 1.5% SB to 2.48±1.5 in those supplemented with 0.0034% VE. Mean corpuscular volume ranged from 93.73±5.7 in those supplemented with 0.0034% VE to 87.05±9.3 in those without supplementation, 0%. Mean corpuscular haemoglobin concentration varied from 32.53±0.70 in those supplemented with 0.0034%VE to 31.97±0.9 in those without supplementation, 0% and the mean corpuscular haemoglobin ranged from 31.05±4.5 in those supplemented with 4.5% SB to 30.40±2.5 in those without supplementation, 0%.

4.25 Serum biochemical indices of broiler breeder hens fed varying dietary inclusion levels of shea butter and palm kernel oil

The serum biochemical indices of broiler breeder hens fed varying inclusion levels of SB and PKO are presented in Table 4.17. The GSH value in the sera of hens on 0.0034% VE (61.3±0.8), 3% SB (61.5±1.4) and 4.5% SB (61.2±0.6) were similar and remarkably higher ($p<0.05$) relative to those not supplementated (59.1±1.6), 1.5% PKO (59.1±0.9) and 3% PKO (59.1±1.6). Greater ($p<0.05$) catalase enzyme component were detected in hens on 3% SB (718.7±170.7) and 4.5% SB (720.2±93.6) compared to those without supplementation (550.7±49.6).

The superoxide dismutase values of the sera of hens on diets containing 4.5% PKO (6.2±1.5) and those on 1.5% SB (6.1±0.9) were substantially ($p<0.05$) higher relative to hens without supplementation, 0% (4.7±1.0), 1.5% PKO (4.8±0.5) and 3% PKO (4.9±0.9) but lower ($p<0.05$) than those on 0.0034% VE (7.2±2.0), 3% SB (7.2±2.1) and 4.5% SB (7.2±2.0). However, ALT and AST values do not differ ($p>0.05$) remarkably by different dietary inclusion and ALT values ranged from 24.0±4.1 in those fed diets containing 0.0034% VE to 31.2±8.1 in those on 1.5% supplemental PKO while AST values varied from 185.7±10.1 in the sera of hens fed ration containing 1.5% SB to 193.9±10.7 in those on 1.5% PKO.

The cholesterol values in the sera of hens on diets supplemented with 1.5% PKO (222.8±62.0), 3% PKO (215.9±65.9), 3% SB (219.7±35.0) and 4.5% SB (220.1±45.5) were substantially ($p<0.05$) greater relative to those without supplementation (159.6±60.1) and 0.0034% VE (158.9±45.7). The triglycerides of the sera of hens fed diet supplemented with 4.5% PKO (191.2±40.1) and 4.5% SB (188.2±48.2) were significantly higher comparatively with the

remaining dietary groups while those without oil or VE inclusion , 0% (136.4±48.7) and 0.0034% VE (132.1±31.9) were the least ($p<0.05$). Hen on diets supplemented with 1.5% PKO (174.7±21.1), 3% PKO (170.9±15.2), 1.5% SB (175.5±23.6) and 3% SB (172.8±34.8) had similar ($p<0.05$) triglycerides.

Table 4.16: Haematological indices of broiler breeder hens fed varying inclusion of shea butter and palm kernel oil

Treatment	PCV (%)	Hb (gm/dl)	RBC(million/ml)	WBC(/ml)	Lymphocytes (/mL)	Heterophil (/mL)	H/L ratio	Monocytes (/mL)	MCV (Fl)	MCHC (g/L)	MCH (Pg)
0 %	30.60±4.0^{b}	8.21±0.9^{b}	3.21±0.7	14640±2122.7^{b}	62.80±8.3	27.80±5.3	0.43±0.2	2.57±0.6	87.05±9.3	31.97±0.9	30.40±2.5
0.0034%VE	29.20±2.9^{b}	9.71±0.6^{ab}	3.23±0.4	19470±4009.2^{a}	65.20±7.5	27.40±4.9	0.42±0.1	2.48±1.5	93.73±5.7	32.53±0.7	30.52±1.9
1.5%PKO	30.20±3.8^{b}	9.73±0.6^{ab}	3.27±0.3	14820±1279.1^{b}	66.00±4.9	30.40±5.8	0.46±0.2	2.60±1.1	89.16±7.9	32.24±1.0	30.80±1.3
3%PKO	39.60±1.5^{a}	9.42±0.5^{ab}	3.21±0.6	14780±2239.6^{b}	64.60±5.9	27.80±2.2	0.43±0.1	2.64±1.7	92.86±1.9	32.27±0.9	30.75±1.7
4.5%PKO	37.00±3.5^{ab}	10.60±1.5^{a}	3.19±0.3	16200±3719.3^{ab}	62.80±7.9	29.40±4.2	0.47±0.1	2.70±0.9	91.15±8.9	32.33±0.6	30.48±4.3
1.5%SB	30.40±2.3^{b}	9.60±0.7^{ab}	3.20±0.9	16400±2581.5^{ab}	63.60±8.1	28.20±4.7	0.44±0.1	2.84±0.2	88.86±9.1	32.37±1.4	30.59±3.1
3%SB	28.60±3.9^{b}	10.62±0.6^{a}	3.20±0.2	18920±3955.4^{a}	63.20±6.7	30.20±7.3	0.48±0.1	2.80±0.6	90.07±6.3	31.99±1.2	30.70±4.3
4.5%SB	38.40±4.4^{a}	10.80±1.9^{a}	3.27±0.4	19290±4972.7^{a}	63.80±7.2	30.00±9.7	0.47±0.1	2.60±1.0	88.14±5.4	32.17±0.9	31.05±4.5
SEM	0.59	0.14	0.18	630.70	1.15	1.10	1.25	0.23	1.24	0.09	0.45

^{ab}Means of treatments along a column with different superscripts are significantly different (P<0.05) ; PCV; Pack cell volume: Hb; haemoglobin: RBC; Red blood cell: WBC; white blood cell :MCV; mean corpuscular volume: MCHC; mean corpuscular haemoglobin concentration: MCH: mean corpuscular haemoglobin; VE- Vitamin E; PKO –Palm kernel oil; SB-Sheabutter

Table 4.17: Serum indices of broiler breeder hens fed varying levels of sheabutter and palm kernel oil

Treatment	Weight (grams)	Heart	Liver	Yolk sac
0%	39.87±1.21^{c}	0.65±0.01^{d}	2.73±0.29^{c}	6.67±0.44
0.0034%VE	48.93±0.76^{ab}	0.81±0.02^{a}	3.19±0.29^{a}	6.53±0.25
1.5%pko	39.73±2.76^{c}	0.70±0.02^{c}	2.73±0.11^{c}	6.44±0.22
3%pko	40.07±1.57^{c}	0.70±0.04^{c}	2.77±0.21^{c}	6.27±0.17
4.5%pko	42.27±2.43^{c}	0.73±0.04^{bc}	2.86±0.17^{bc}	6.53±0.26
1.5%SB	40.67±1.03^{c}	0.75±0.05^{b}	3.06±0.20^{ab}	6.39±0.21
3%SB	51.40±1.34^{a}	0.81±0.01^{a}	3.12±0.15^{ab}	6.43±0.37
4.5%SB	48.47±3.06^{b}	0.79±0.01^{a}	3.12±0.18^{ab}	6.50±0.23
SEM	0.78	0.01	0.04	0.04

^{abc}Means with different superscripts are significantly different (P<0.05) : SOD; superoxide dismutase :GSH; Reduced glutathione: ALT; Alanine amino transferase: AST; Aspatate amino transferase; VE-Vitamin E

CHAPTER FIVE

5.0 DISCUSSION

5.1 Chemical profiling of selected vegetable oils rich in vitamin E

From the current study, saponification value of palm kernel oil (PKO) was 249.9 mg/KOH/g and it was observed to be the highest among the three oils considered. This was followed by shea butter which has 190.9 mg/KOH/g while sesame seed oil has the least saponification value of 15.8 mg/KOH/g. The saponification values obtained for palm kernel oil were similar to what was observed by Mohammed and Hamza (2008) who recorded a value of 247 g/KOH/g for palm kernel oil but lower saponification values for other categories of lipids such as corn oil (187-196) and groundnut oil (188-196). However, the values obtained in the current study for sesame seed oil (15.8 mg/KOH/g) were contrary to what was reported by Mohammed and Hamza (2008) for sesame seed oil (189-190 mg/KOH/g). Ezema and Ogujiofor, (1992) reported that the saponification values of shea butter mostly fall between 132 mgKOH/g and 207.5 mgKOH/g (Womeni *et al*., 2004). Sheabutter also contain impurities that are not soluble.

Saponification value can be used to predict the molecular weight of the component fatty acids in the oil. The higher the saponification value, the lower the molecular weight of the constituent fatty acids (Ezeagu *et al.*, 1998). The report of this research was in consonance with that of Akihisa *et al.* (2010) who asserted that sheabutter consisted of triglycerides and unsaponifiable components, which are important basic product for the manufacture of soap and cream. Similarly, Njoku *et al*. (2000) reported a value range of 1.2% to 17.6% for the unsaponifiables in sheabutter. However, Adriaens (1943) observed a converse correlation between the fruit ripeness and the degree of unsaponifiables, while Ruyssen (1957) reported that the measured unsaponifiables in fruit is different on yearly basis and also depends on environmental variations. Most vegetable oils have lower unsaponifiables compared to shea butter (Dhellot *et al*., 2006).

The iodine values observed in the oils were not significantly different, although sesame seed oil (6.9g/100g) had the highest value. Iodine value states the degree of saturation or unsaturation of the oil or fat. It is important in the determation of the shelf life of the oil because iodine numbers have a direct proportion with the degree of unsaponification, and an inverse relationship with the shelf-life. Iodine value of oil or fat is the amount of iodine that can be engrossed by 100g of the oil or fat. It is important in the determination of the degree of reactivity of the oil. Lipids with greater iodine values contain more double bond than those with lower iodine values. In the present study, palm kernel oil with iodine value of 4.7g/100g is the most saturated of all the oils that were considered, however, Dawodu *et al.* (2015) observed a higher iodine value of 23.52 g/100g for palm kernel oil at a temperature of 25^{o}C.

Sesame seed oil had the lowest peroxide value of 0.3 meq/kg compared to palm kernel oil which had 0.7 meq/kg while shea butter had the highest at 7.4 meq/kg. The report from the present study corroborates the findings of Njoku *et al.* (2000) who recorded value ranges of 0.5 to 29.5 meq O_2/kg. In the soap, cream and confectionaries production, the peroxide value range of shea butter to be used varies from 1 to below 10 meq O_2/kg (Kassamba, 1997).

Peroxide formation are slow when fats and oil is stored because of an induction period depending on the type of oil and its temperature. Peroxide values are indicators which detect the rate of rancidity of oil and it shows the extent at which the oil had undergone primary oxidation. Oils containing greater composition of unsaturated fatty acids are more likely to receive oxygen and become rancid compared to their counterpart with lesser unsaturated fatty acids. CODEX, (1999) recommended a maximum peroxide value of 10 milliequivalent of active oxygen per kilogram for fats and oils suitable for consumption hence, all the oils under consideration in the present study are suitable for consumption.

Higher acid value was observed in PKO compared to sheabutter and sesame seed oil. The acid value of lipids indicates the rate of decomposition of triglycerides by lipases or other exposures including heat, light and temperature. It can be used to determine oil state and edibility. The acid values for sheabutter differ from 0 mg KOH/g as observed by Womeni *et al*. (2006) to 21.2 mg KOH/g (Nkouam *et al*., 2007) and the observed value in current study was consistent with reports of these authors. However, Nkouam *et al.* (2007) observed higher figure of 128.2 mg KOH/g in CO_2 extracted shea oil from shea seed that had been preserved over a prolong period

of up to two years. However, comparing the result of the acid value of the lipids under consideration in the present trial, it can be deduced that PKO hydrolysed the most.

The α-tocopherol value of sheabutter was 119.18±5.80 mg/mL and was higher compared to sesame seed oil with α- tocopherol value of 69.6±2.21 mg/mL and palm kernel oil with the value of 24.37±1.25 mg/mL. The relatively high α-tocopherol of shea butter established the assertion of Allal *et al*. (2013) who recorded a value of 112 mg/100g of butter, however, this was contrary to what was recorded by Okullo *et al*. (2010) who recorded a low α- tocopherol range of between 26.3 mg/100g and 44.4 mg/100g for shea butter grown in Uganda. It has however been observed that factors such as environment, genetic influences and storage period all affect the α-tocopherol concentration of fats and oil. This is because some of the α-tocopherol were used up during the period of storage to fight free radicals. David *et al*. (2001) also observe a very high concentration of tocopherol in sesame seed oil although a large proportion of it exist as gamma tocopherol. Sheabutter had significantly higher total carotene content of 7533.20µg/mL compared to PKO (3041.10) and SSO (4624.30). This may be the reason for the light yellowish colour of shea butter.

Fatty acid composition of oils or fats is one of the most vital attribute that can be used to determine its identity. From the current study, oil type differed significantly in fatty acids profile. Caproic, caprylic, capric, lauric and myristic acids were significantly higher in PKO compared to SSO and SB, while palmitic, linoleic and behenic acids were greater significantly in SSO when compared to PKO and SB but stearic, oleic, arachidonic, palmitoleic and linolenic acids were significantly higher in SB compared to PKO and SSO.

From the screening carried out in the current study, the ratio of saturated/unsaturated fatty acid for the oils are 94.59%/5.95% for PKO, while SB was 47.48%/52.04% and SSO was 15.16%/84.72%. According to White (2000), there are three main considerations for classification of oils as being healthy and it include a balanced proportion of saturated/unsaturated fatty acid, a balanced proportion of essentials fatty acids (omega 6/omega 3) and the content of innate antioxidants. From the above consideration, SB was observed to contain a better proportion of saturated to unsaturated fatty acid and this agreed with the observation of Di Vincenzo *et al*. (2005) reported about 16 fatty acids from shea kernels samples selected from different regions and the most prominent ones are oleic, stearic, palmitic, linoleic,

and arachidic acids. The most abundant fatty acid reported is oleic acid, which varied from 37.2% to 60.7% (Akihisa *et al*., 2010). Stearic acid is the next most abundant varying from 29.5% (Okullo *et al*., 2010) to 55.7% (Akihisa *et al*., 2010). Some authors (Maranz *et al*., 2004; Di Vincenzo *et al*., 2005; Akihisa *et al*., 2010) observed variations in the shea butter fatty content from Uganda and other West African countries. The authors reported that a higher value of oleic acid for butter from Uganda while stearic was higher for the other regions. On the contrary, in the present study, oleic acid percentage of shea butter was higher at 44.82% compared to 42.47 recorded for stearic. The report on the palmitic acid content of shea butter were not consistent with what was obtained by Okullo *et al*. (2010) who recorded a value of 7.5% as against 4.01% reported in the present trial however, Di Vincenzo *et al*. (2005) obtained a percentage of 3.4% for palmitic acid. The stated linoleic acid composition of 5.5% (Mendez and Lope, 1991) were consistent with the result of the current trial of 5.57% but lower than what was obtained by Mbaiguinam *et al*. (2007) which was 7.9%. Kaur *et al.* (2014) observed that linoleic acid is an important fatty acid because it is not synthesised by the body and it is critical in the building of the cell membrane.

The report of the current study for the linoleic component of shea butter was in agreement with Maranz and Wiesman (2004) who reported a value of 6–8% for shea butter thereby making it vital in human nutrition. Arachidic acid recorded for the present trial (1.15%) were higher than those reported by Mendez and Lope (1991) at 0.6% while the linolenic acid stated in literature varied from 0.2% to 1.6% (Tano-Debrah and Ohta, 1994) while 0.25% was recorded for the current study for shea butter.

From the report of the current study, although all the oils are suitable for livestock consumption, shea butter had a richer spectra of tocopherol and total carotene composition. This important indices made it more suitable for inclusion in the diet when compared to sesame seed oil. However, two of the oils (Palm kernel oil and Sheabutter) were eventually selected to be used in the feeding trial based on the frequency of their usage in the breeding industry, fatty acid profile and the alpha tocopherol content of the oil.

5.2 Effect of varying levels of vitamin E supplementation on performance, blood profile, egg internal and external characteristics of broiler breeder hen

In the present experiment, varying inclusion of vitamin E significantly affected haugh unit and albumen height, but not yolk height, yolk diameter, yolk weight and albumen weight. However, egg external attributes were not altered by varying inclusions of α-tocopherol (0 to 100IU/kg). The result observed in this trial is consistent with what was obtained by Yan and Kim (2013) who noted that haugh unit scores and vitamin E concentration in yolk were expressively affected by dietary vitamin E addition of upto 310 mg/kg. However, Radwan *et al*. (2008) noted no remarkable variation in haugh unit when layers were placed on diet containing tocopherol (100 or 200mg/kg) although, the author observed that supplementing upto 200 mg vitamin E/kg resulted in an ascending increment in the shape index and egg shell percentage of the hens.

The result of current trial confirmed the report of Puthpongsiriporn *et al.* (2001) who concluded that VE levels greater than 20 IU kg-1 diet resulted in an increase in internal egg quality in laying hens as reflected in an increased haugh units in birds fed 60 IU VE kg-1 comparable to 20 and 40 IU /kg. Increased maternal α-tocopherol in the feed improves antioxidant grade of egg and prevent amino acid and fats of egg from peroxidation (Puthpongsiriporn *et al*., 2001), having positive effect on haugh unit and undoubtedly hatchability. The ovomucin component of the albumen increase with an increase in haugh unit in eggs of young birds. According to Lapao *et al*. (1999), haugh unit is age related and there is a relationship, between egg haugh unit and its ability to hatch. Hagan and Eichie, (2019) reported albumen's deterioration especially lysozyme and ovomucin dissociation as a result of pH increment (at 35 weeks of age) thereby reducing albumen viscousity and consequently declined haugh unit. Nwachukwu *et al*. (2006) posited that higher haugh unit scores are indicative of high quality hence from the report of the current study, it can be deduced that eggs collected from the treatment supplemented with 40IU/kg and 60IU/kg were superior to the other treatments even before setting them in the incubator. This maybe due to the ability of vitamin E to prevent lipoperoxidative damage to the yolk.

From the current study, α-tocopherol deposition in eggs of broiler breeder hens was significantly higher in birds on 80IU/kg and 100IU/kg dietary vitamin E as additional inclusion of dietary vitamin E causing an increment in the deposition of α- tocopherol in eggs. This increasing trend of α-tocopherol component of the egg may be due to the fact that egg having a greater

concentration of trapped lipid were able to absorb more α-tocopherol being a lipid soluble vitamin when high in the ration.

Total carotene deposition in eggs of broiler breeder hen are unchanged by varying vitamin E levels. The result showed that the fat soluble vitamins were absorbed differently and that excess of one did not increase the absorption of others.

Supplemental vitamin E at 40IU/kg significantly improved hen day egg production (89.21%), egg mass (57.43g) compared to other treatments and the FCR of birds and efficiency of production was improved at 40IU/kg supplemental vitamin E. Hatchability (94.80%) of broiler breeder eggs was optimally observed at 37IU/kg supplemental vitamin E. These results validate the assertion of Perez-Vendrell *et al*. (2003) who recorded an increased vitamin deposition in the eggs of layers in response to fortification of their diets with vitamins commonly used in Spain.

Bollengier-Lee *et al.* (1998) reported a remarkable decrease in FCR value due to vitamin E addition. The improved FCR due to additional vitamin E inclusion may be due to the nutrient protecting capacity of tocopherols, thereby enhancing feed intake, nutrient absorption and utilization as well as protecting vital tissues damage induced by stress. Conversely, Meluzzi *et al*. (2000) recorded no substantial difference in feed intake and FCR of Hy-Line Brown layers offered ration containing tocopherol at inclusion ratios of 0, 45, 90 and 180 IU/kg diet. The authors observed that the inclusion does not also impact the recorded daily egg produced or egg output over the trial period. Also, Grobas *et al*. (2002) observed no variation in egg produced by ISA brown layers fed ration containing additional α-tocopherol at inclusions 13-263 mg/kg of feed. Conversely, Bollengier-Lee *et al*. (1998) posited that layers on tocopherol complemented diets at an inclusion of 125-500 mg/kg in feed showed an increased egg production and ascribed the improved outcome to the release of vitellogenin from the liver causing the elevation of blood vitellogenin level. Jiang *et al.* (2013) also validated the assertion that feeding layers rations containing additional vitamin E improve egg production.

The report on hatchability in this study are attuned with research of Hossain *et al.* (1998) who supplemented the feed with graded levels of VE kg-1 in Ross breeder ration and reported that those on 50 mg/kg VE produced the most number of chicks per fertile eggs at week 40. However, Lin *et al*. (2004) observed no difference significantly on hatchability of Taiwan native chickens when vitamin E were supplemented. Leeson and Summers (1991 and 1997) made a

recommendation of 20-25 mg of VE /kg for inclusion in breeders broiler feed. But, newer broiler breeders strains require additional VE supplementaion. Therefore, from the current research a VE inclusion of 37 IU kg-1 in Arbo acre plus broiler breeder diet for improved hatchability is recommended.

From the current study, varying concentration of α- tocopherol in the maternal diet significantly affected relative weights of organs of hatched chicks, with higher values obtained in body weight, heart and liver of birds on 40IU/kg supplemental α-tocopherol. This was consistent with the work of Surai, *et al*. (2016) who posited that dietary vitamin E derived from the ration of the hen are deposited in the egg and subsequently to embryonic tissue before being utilised by the chicks. Selim *et al*. (2012) observed a higher body weight in ducklings produced from eggs that are inoculated with vitamin E in-ovo although the author observed a decline in the relative organ weight of the heart and liver of the ducklings. According to Kling and Soares (1980), vitamin E is important for hatchability. The VE requirement of breeder hens is usually assessed based on egg production and hatchability, but putting other requirements (such as physiological requirements) into consideration, this recommendation may differ (Tengerdy and Nockels, 1973). However, NRC (1994) is not specific about the VE requirement for broiler breeders but in layers breeders on a daily ration consumption of 100 g/hen/day, the required amount is 10 mg kg-1 diet.

Haematological indices of broiler breeder hens in this study revealed that varying amount of supplemental vitamin E significantly affected haemoglobin concentration, RBC, WBC and Monocyte values, but PCV, lymphocyte, heterophils, heterophils to lymphocyte ratio, MCV, MCHC and MCH were not influenced. The result obtained for haematology in the present study were not consistent with what was obtained by Al-Nedawi (2018) for commercial Ross 308 broilers. This may be due to the fact that haematological parameters vary widely depending on the age, sex, type of diet, climatic conditions, strain, weight of birds. Increasing concentration of dietary vitamin E significantly increases GSH concentration in the Serum and this trend was also observed for catalase and SOD. Although no significant differences were observed for ALT, AST and cholesterol values. Haematology is the study of the number and morphological status of the cells of the blood and it is a good indicator for testing the consequences of feeding trials on the animal health conditions in terms of reproduction, growth and maintenance. The result on

white blood cell count reported in this trial were consistent with what was obtained by El-Sebai (2000) who reported an increase of upto 4.65% in vitamin E supplemented group of broilers when compared with those without supplementation and this may help improve the ability of the vitamin E group to fight disease more when compared to those not supplemented due to the phagocytic function of the macrophages, however, Swain *et al*. (2000) reported no variation in haemoglobin concentration of broilers when vitamin E were fed to broilers. The numerous functions of vitamin E include the protection of cells playing roles in disease prevention (such as lymphocytes, macrophages and plasma cells) from peroxidative destruction, antibody production and to boost the performance of these cells. Haq *et al.* (1996) showed that VE supplementation of breeder feed improved the ability of offsprings to fight against Newcastle Disease Virus (NDV). However, the fact that there was no significance in the lymphocytes, heterophils and heterophils to lymphocyte ratio between the treatment in the current study suggested that inclusion of varying amount of vitamin E had no impact on the counts and that the hens are not under any severe physiological stress. This was contrary to what was obtained by Minka and Ayo (2008) who observed a noticeable difference in the H/L ratio when another antioxidant, vitamin C was offered to layers after transportation.

Vitamin E supplementation was observed to positively influence the antioxidant enzyme activities in the blood stream as observed in the higher values of GSH, SOD and catalase and this agreed with Bollengier-Lee *et al*. (1998). The increased enzymatic activities neutralise free radicals thereby reducing lipoperoxidative damage in the blood of the vitamin supplemented hens. SOD reduces superoxide radicals to H_2O_2 which are inturn reduced to H_2O and O_2 by catalase. Generally, the nutrient levels required for growth maybe inadequate for sufficient immunity response and disease resistance (Nockels, 1988).

5.3 Effect of selected dietary oils on performance, egg characteristics and blood profile of broiler breeder hen

From the current study, varying levels of dietary oils significantly affected α- tocopherol and total carotene deposition in eggs of broiler breeder hens. Higher deposition were observed in diets fed 3% and 4.5% shea butter oil and this may be due to higher α-tocopherol and total carotene content of sheabutter. Dimitrov *et al*. (1991) noted that fat soluble vitamin absorption

improve with increased intake of dietary fat. Lin *et al.* (2004) posited that the nutrient profile of eggs are greatly altered by dietary manipulation of the maternal diet. Also, HDEP, egg weight, egg mass and FCR of Arbo acre plus hens were significantly different. However, hen weight were not significantly affected and ranged from 4.29 to 4.64 kg and this is in consonance with Brake *et al.* (1989) who observed that body weight of broilers remain the same when animal or vegetable fat of upto 5% were added to the feed of broiler parent stock .

Oil sources significantly affected breeding efficiency of broiler breeder hens as observed in this study. A 3% and 4.5% SBO inclusion in diet resulted in significantly higher fertility (94.39 to 95.50%) and hatchability (94.54 to 95.83%) compared to PKO, but was commensurate to 37IU/kg supplemented vitamin E. The hen day egg production reported in this study were lowered with increased addition of palm kernel oil upto 4.5% and this agreed with the research conducted by Peebles *et al*. (2000) who reported a decline in egg production in broiler breeders fed increased component of saturated fatty acids and this can be due to reduced follicular development.

Egg weight was observed to be highest in the treatment supplemented with 37IU/kg VE although this cannot be said for the chicks weight because the chicks in the treatment fed 3% shea butter oil were significantly bigger than other chicks in the other treatments. This does not agree with the assertion of Abiola *et al.* (2008) that egg weight positively influence chick size. However, this maybe due to increased composition of unsaturated fatty acids in shea butter oil and this assertion was corroborated by the study of Fernandes *et al.* (2018) who observed bigger chicks when oil from soya were added to maternal feed.

The result obtained for FCR were not consistent with what was obtained by Athari and Watkins (1988) who observed no significant difference when broilers were fed diet containing 5% saturated fat and soya oil. However, the report was in consonance with what was recorded by Machlin *et al*. (1962) who stated a decreased egg production (from78% to 25%), fertility (37%) and hatchability (0%) when white Leghorn layers were supplemented with base diet containing upto 7% of unsaturated fatty acid and antioxidant (20IU/pound in feed) for 56 days. However, a replacement of the diet with higher quantities of both unsaturated acid (7%) and VE (100 pound/kg) over the same period of time resulted in an increased egg output to 57%, 67% of the egg produced were fertile and chicks hatched per fertile eggs was also 67%. The authors then

concluded that free radical scavenging ability of vitamin E inhibited the degradation of the unsaturated acid, which could have led to lipoperoxidative damage. In addition, layers placed on diets lower in unsaturated fatty acid do not need any supplementation to prevent lipoperoxidative damage. Similarly, Yoshida and Hoshii (1976) carried out an experiment supplementing a different unsaturated fatty acid i.e 12% dilauryl succinate, similar in activity to the fatty acid supplemented by Machlin *et al.* (1962), the total chicks per unit of egg production was also observed to be low. However, the negative effect was reversed by the addition of 200 mg/kg feed of *dl*-α-tocopheryl acetate to the similar diet (Yoshida and Hoshii, 1976).

From current study, Palm kernel oil supplementation at various inclusion levels (1.5, 3.0 and 4.5%) significantly lowered chicks weight of chicks hatched compared to the chicks weight of chicks hatched in the treatment supplemented with 3% sheabutter. The observed effect might be as a result of the saturated nature of Palm kernel oil which increased digesta viscousity thereby reducing nutrient absorption in hens in the treatment supplemented with palm kernel oil. The multiplier effect is a reduction in the nutrient deposition in the eggs required for embryonic development and hence a resultant reduction in chicks weight and this agreed with the observation of Mohammed *et al*. (2005).

With respect to the poor egg quality characteristics caused by the presence of total carotene and tocopherol contained in the dietary oil supplementated in this study, moderate clarification by the report of Grobas *et al.* (2002) confirming that higher quantities of dietary vitamin A reduce vitamin E uptake as observed in birds on high levels of dietary oils. Similar observation were raised by Lin *et al*. (2002) who ascertained that layers had increased feed consumption when fed diets supplemented with beta carotene (3,000 to 12,000 IU/kg) in the period of heat stress. Also, Abdo (2009) recorded a remarkable increase in feed intake due to dietary supplementation with 1.8 mg vitamin A/kg compared to those without supplementation. On the contrary, Kaya *et al*. (2001) observed no variation in feed intake for layers on supplemental vitamin A (6 mg/kg diet), however, egg production recorded a significant improvement in the treatment fed supplemental vitamin A compared to those without supplementation. Improved egg production in the vitamin supplemented group (4.8 and 9.6 mg/kg diet) may be due to improved FI and FCR.

On the contrary, Ramalho *et al*. (2008) observed no significant variation on egg output when retinyl palmitate (0.054, 0.108, 0.216 and 0.432 mg/kg diet) were included to laying quail feed.

Sahin and Kucuk (2001) established that the addition of vitamin A and vitamin E enhanced diet intake of Japanese quails raised in hot climatic condition. The trials conducted by Lin *et al.* (2002) established an improvement in the laying performance of layers during heat period due to the interactive effect of vitamin A and vitamin E. This assertion was corroborated by Abdo (2009) who revealed that layers supplemented with diets enhanced with 2 stages of vitamins A and E individually or combined may produce a significantly higher average values of egg production.

Conversely, Abd El-Hack *et al.* (2019) observed no significant effect arising from supplementation of vitamins A and E inclusion on egg characteristics. However, vitamin A alone had a significant negative impact on egg shape index while vitamin E had impact on eggshell thickness. Higher levels of beta carotene in the diet resulted in a noticeable decline in egg shape index value. Similar observation were recorded for increased dietary vitamin E which imposed a thinner eggshell. Egg content percentages, shell integrity and haugh unit score were also not impacted by inclusion of vitamin A. The outcome obtained from this study for egg quality parameters agreed partially with the observation of Ramalho *et al*. (2008) who established a significance in egg quality parameters due to the supplementation of hens feed with retinyl palmitate at graded levels. Abdo (2009) observed that eggshell amount relative to whole egg improved with addition of beta carotene at the dietary inclusion of 10 IU/kg in ration. The impulsive ability of vitamin A on the growth and development of female reproductive system may be the cause of the enhancement in egg quality parameters (Alais and Linden, 1999).

In contrast, Bárdos *et al.* (1996) obtained no remarkable variance in egg quality traits of Japanese quail when placed on a feed containing additional beta carotene. On the other hand, Yuan *et al*. (2014) reported that the egg shell of broiler were thinner significantly when beta carotene were added to the feed at inclusion of 45,000 IU/kg. Observation from this study agreed with the assertion of Abdel-Fattah and Abdel-Azeem (2007) who observed a better egg superiority characteristics in laying quail fed diet containing graded inclusions of vitamin E compared with those without supplementation. The antagonistic tendencies which occur between vitamins A and E may be due to the rivalry that occur in the process of digestion and absorption because both are fat soluble vitamins and they are incorporated together with triglycerides, lipoproteins and

phospholipids to form chylomicrons which are secreted into the lymphatic tissues. However, antagonism could be reduced by administering vitamin E individually.

From the current study, the PCV, Hb and WBC values of breeder hens were noticeably altered by varying supplemental sheabutter and PKO. A 4.5% inclusion of Shea butter or Palm kernel oil significantly increased PCV and Hb values compared to 37 IU/kg supplemental vitamin E. Shea butter oil at inclusion levels of 3% and 4.5% resulted in a higher and commensurate value of GSH, catalase and SOD compared to 0 IU/kg supplemental vitamin E but not cholesterol and triglycerides. These report contradicted that of Yuan *et al.* (2014) who noted that addition of supplemental vitamin A at 135,000 IU/kg dietary inclusion to broiler breeder diets reduced the multiplication of blood lymphocytes. The authors however noted that α-tocopherol supplementation significantly influence the quantities of monocytes and basophils. Vitamin E inclusion at 500 mg/kg in the diet multiply monocyte count by 11.90% compared with those without supplementation. On the contrary, basophil count was noticeably decreased with increased vitamin E supplementation. The result of present study substantiate the research of El-Sebai (2000) who reported an elevation of the white blood cell count of the blood of broilers with a corresponding increase in vitamin E supplementation to broiler diets relative to those without supplementation. Vitamin E improves the immune functions of chickens because of its antioxidant and immunomodulatory properties which enhance the phagocytic function of the macrophages (Perez-carbajal *et al*., 2010).

Abd El-Hack *et al.* (2019) reported noticeable alterations of the hematological parameters of hens offered ration containing additional vitamins A and E. The authors observed the most value for PCV (40.09%) and Hb (10.33 mg/100 mL) in the condiment containing vitamin A and vitamin E at 0 IU and 500 mg/kg respectively while the highest lymphocytes count was observed in samples from layers offered a condiment of 4.8 mg vitamin A plus 250 mg vitamin E/kg diet. The layers on the feed supplemented with a combination of 4.8 mg vitamin A and 0 mg/kg vitamin E had the most monocytes count while those on 9.6 mg vitamin A and 250 mg vitamin E/kg in the ration had significantly higher eosinophil counts in the blood of hens in that treatment compared with the others. The authors then attributed the effects to the interaction of the vitamins which resulted in the synergistic effect between them. This assertion was supported by Haq and Bailey (1996) who reported that the combining vitamins A and E in the diets of

chickens as vital micro-nutrients can result in the proliferation of their blood lymphocytes. However, Abdelnour *et al*. (2018) observed a significant decrease in hemoglobin content, platelet count and mean corpuscular volume when a combination of black pepper oil and red pepper oil (which were reported to have antibacterial and antioxidative effect) were fed to rabbit. According to Ford *et al*. (2006), the common forms of vitamin E in the blood are α-tocopherols while vitamin A, and provitamin A are retinol and β-carotene respectively (Tanumihardjo *et al*., 2016). These fat-soluble vitamins play vital roles in the physiological systems (Gagne *et al*., 2009). Jiang *et al*. 2001 however observed that though α-tocopherols are the common circulatory form of vitamin E, γ-tocopherol is the most available form of vitamin E in the diet.

In the current study, supplementation with vitamins A and E rich oils did not alter ALT and AST. This was in contrary to the report of Abd El-Hack *et al.* (2018) who observed at noticeable decline in ALT values due to supplemental vitamin A during heat stress condition. The authors also observed a significantly higher serum AST levels with increased supplementation of vitamin A. However, the observation were similar with the assertion of Francini *et al*. (1990) who fed older turkeys with diets supplemented with graded inclusions of vitamin E but observed no significant variation in both ALT and AST but the authors observed a significant increase in AST level with vitamin E inclusion in young turkeys. From the current study however, it may be deduced that the non significance of the liver enzymes (AST and ALT) may be due to unchanged metabolic activities due to supplementation and this may be as a result of the age of the hens because they are not actively growing.

The result obtained for the GSH in the present study were consistent with what was obtained by Ozturk-Urek *et al.*(2001) who offered chickens with ration containing selenium and vitamin E. The authors observed a significant elevation of the activities of GSH in the serum compared to those without supplementation. The result can be comparable with the findings of this study with the increased activities of GSH which were observed in the treatments supplemented with oils rich in beta carotenes and tocopherols and this may be due to the antioxidant effect of the fat soluble vitamins which improved the activities of the primary antioxidant enzyme. The report on catalase activities obtained in this study contradict the observation of Avanzo *et al.* (2001) who obtained a converse association between vitamin E and selenium supplementation and catalase activity.

Lipid metabolites in the chicken blood, including triglycerides concentration, total cholesterol, lipoprotein fractions, as well as the fatty acids profile, are sensitive indicators of fat metabolism intensity in the organism. Total cholesterol and triglycerides in the serum of the hens used in this study was observed to be higher with the inclusion of both palm kernel oil and sheabutter. This could be attributed to an increased deposition of fat in the blood of the hens as a result of both saturated and unsaturated fatty acids present in the diets of hens supplemented with higher levels of palm kernel oil and sheabutter. This agreed with the work of Duraisamy *et al.,* (2013) who reported an increment in the meat total cholesterol level of broilers fed saturated and unsaturated fatty acids. Although, no significant difference was observed when palm kernel oil (with higher composition of saturated fatty acid to unsaturated fatty acid) or sheabutter (containing an almost equal ratio of saturated to unsaturated fatty acid) were added to the diet, Sanz *et al*., (1999) reported that saturated fatty acids especially animal based such as tallow deposit more total cholesterol in the body compared to unsaturated ones. Similarly, Kucuk *et al*. (2003) reported that addition of vitamin A elevated plasma component of total protein in broilers and reduce cholesterol content. The results of present findings validated that of Abd El-Hack *et al*. (2018) who observed an elevated cholesterol and tryglyceride values when Bovans brown layers were fed vitamin E supplemented diets under hot climatic conditions. The authors noted that it may be ascribed to the antioxidative capability of vitamin E which prevent lipoperoxidative damage caused by the temperature rise. On the contrary, no observable variation were noticed on other blood metabolites.

El-Sebai (2000) reported a considerable rise in serum total protein, tryglycerides and total cholesterol of trial groups offered ration containing α-tocopherol as against the control. However, Abd El-Hack *et al*. (2015) affirmed that nutritional inclusion of α-tocopherol at the rate of 250 mg/kg in feed had no influence on serum metabolites of broiler chickens.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

The experiment was conducted to test the consequences of supplementation of vitamin rich oils as a replacement for the supplementation of the conventional vitamins that are used to improve the reproductive efficiency of broiler breeder. Three experiments were accompanied in this study:

The first experiment involved the screening of the oils to determine the ones that are most frequently used in the breeding industry and the one with the better profile of vitamin. In the first experiment, three oils were assayed and these included palm kernel oil (PKO), sheabutter oil (SB) and sesame seed oil (SSO

The second experiment involved the addition of α-tocopherol to the diet of broiler breeder hens. Graded levels of tocopherol at 0, 20, 40, 60, 80 and 100 $IUkg^{-1}$ were supplemented in the basal ration of Arbor Acre plus breeder. One hundred and eighty arbor acre plus broiler breeders hens, aged 30 weeks were randomly allotted in a completely ramdomised design into 6 treatments and replicated 5 times with 6 hens per replicate. Egg quality parameters, vitamin deposition in egg, performance, reproductive efficiency, haematology and serum biochemical parameters were observed. The optimum vitamin E levels were also determined using regression analysis.

The third experiment involved the supplementation of graded levels of the selected oils together with the optimum vitamin level obtained in the second experiment to basal diets of broiler breeder hens diet. Two hundred arbor acre hens, aged 42 weeks were randomly allocated in a completely randomized design into 8 treatments, 5 replicates and 5 hens per replicate. The basal ration were supplemented with 0, 1.5, 3.0, 4.5% palm kernel oil, 1.5, 3.0, 4.5% shea butter and

37 IU/kg vitamin E. Egg quality parameters, vitamin deposition in egg, performance, reproductive efficiency, haematology and serum biochemical parameters were also observed. The optimum oil inclusion were also determined by regression analysis

6.2 Conclusion

Iodine values of the three oils under consideration were similar. However, the saponification value of PKO were higher relative to the others. The peroxide value was higher in shea butter relative to the remaining two oils. The degree of free fatty acid present in PKO was higher in relation to SB and SSO as reflected in the higher acid value that was observed in Palm kernel (25.29±2.46) when compared to that of Shea butter (10.65±1.00) and sesame seed oil (17.21±3.22). Higher α-tocopherol concentration of 119.18±1.25 was observed in shea butter compared to palm kernel oil and sesame seed oil which had 24.37±1.25 and 69.57±2.2 respectively. Shea butter (7533.20±264.09) also contain more total carotene compared to palm kernel oil which had 3041.10±144.01 and sesame seed oil with 4624.30±107.3, and this may account for the light yellowish colour of Shea butter. Shea butter is limited in caproic, caprylic, capric and behenic acids, palm kernel oil do not contain arachidonic, linolenic, palmitoleic and behenic acids while sesame seed oil do not contain caproic, caprylic, capric, lauric, linolenic and palmitolic acids . However, palm kernel oil which is also called lauric oils had higher content of lauric acid (43.55±0.9%) compared to shea butter (0.74±0.06%).

Inclusion of tocopherol at 40 $IUkg^{-1}$ and 60 $IUkg^{-1}$ resulted in higher haugh units of 82.71±4.71 and 83.97±3.55, respectively, compared to other dietary treatments. Some internal egg parameters such as yolk height, yolk width, albumen weight and yolk weight were unchanged by the addition of supplemental viatmin E in the diet of broiler breeder hens. However, none of the external egg parameters were influenced by the inclusion of supplemental tocopherol to the ration of broiler breeder hens. The highest α-tocopherol content were obtained in eggs of hens on ration supplemented with 80 IU/kg (9.17±0.57) and 100 IU/kg (9.11±0.40).

An optimum α-tocopherol concentration in the egg was observed at 100 IU/kg although the treatment supplemented with 80 IU/kg and 100IU/kg were statistically the same. Dietary addition of tocopherol had no noticeable influence on hen weight, egg weight and mortality but it

affects hen day egg production, egg mass and FCR. The highest egg output (HDEP) was observed at 40 IU/kg and was 89.21±7.12% and egg output of broiler breeder chickens was only 66% dependent on the presence of supplemental tocopherol.

Optimum hatchability of 94.80% was obtained at 37 IU/kg inclusion of tocopherol to the diet of broiler breeder chicken. Supplemental tocopherol significantly affected haemoglobin concentration, RBC, WBC, and monocytes, with higher values observed in birds on 100IU/kg. However, the PCV, lymphocyte, heterophils, MCV, MCHC, and MCH were unaffected. The GSH, catalase, and SOD values were higher in birds on higher quantities of supplemental tocopherol (40 to 100 IU/kg).

6.3 Contributions to Knowledge

- Shea butter has a higher α-tocopherol of 119.18µg/mL when compared to palm kernel oil (24.37µg/mL) and sesame seed oil (69.57µg/mL)
- Dietary α-tocopherol supplementation of up to 37 IU/kg improved egg fertility and hatchability up to 95.23 % and 96.19 %, respectively
- Dietary supplement of shea butter at 3.2 % inclusion, improved fertility up to 95.60% and hatchability to 96.00%

6.4 Recommendation

For optimum egg production and hatchability in broiler breeder hens, an optimum inclusion level of 37 IU/kg supplemental vitamin E or 3.2% sheabutter in the diet is recommended.

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