EFFECT OF DIETARY INCLUSION LEVELS OF DIATOMACEOUS EARTH ON PRODUCTION AND CARCASS CHARACTERISTICS OF BROILERS

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Effect of dietary inclusion levels of diatomaceous earth on production and carcass characteristics of broilers

ABSTRACT

This study was done to investigate the effect of diatomaceous earth (DE) inclusion levels on the growth performances and carcass quality characteristics of broilers. A total of 750 as-hatched day-old Arbor Acres broiler chicks were randomly allocated to five experimental treatments (n=150 birds/treatment). A standard commercial broiler diet consisting of a three phase feeding regimen (Starter: D0-16, Grower: D17-35 & Finisher: D36-42) was used during the experimental period as the control diet (0% DE inclusion). All the broilers received the control diet for the first 16 days, without any additional DE supplementation. From D17 onwards (25 day period), birds received their respective experimental diets whereby the DE was mixed with the control diet at respectively 0.5%, 1.0%, 1.5% and 2.0% inclusion levels. Feed and water provision was at an *ad libitum* basis throughout the experimental period, whereas a photoperiodic period of 18 hr light and 6 hr darkness (18H:6D) were used. Brooding temperature was gradually decreased from 33 ˚C (D0) to 24 ˚C on D21 of age, while birds were housed on pine wood shavings at a floor density of 11.5 birds/m^2. At D42 of age, 24 birds/treatment (n=12♂ & 12♀/treatment) were fasted overnight before being weighed and slaughtered. Internal organs such as the heart, gizzard and liver weights were recorded after evisceration of the carcasses, while carcasses were cut into eight-piece portions to determine the effect of DE inclusion on carcass characteristics.

Data were statistically analysed (P <0.05) using a fully randomised one-way ANOVA procedure. Treatment 5 (2.0% DE inclusion) resulted in the highest (P <0.05) feed conversion ratio (FCR) (2.07) and the lowest (P <0.05) performance efficiency factor (PEF) (272). In general, it can be concluded that dietary DE inclusion level had no effect (P >0.05) on most of the production and carcass quality traits. The results of the present study suggest that the inclusion of up to 1.5% DE in broiler diets during the growing and finishing phases will not have (P >0.05) a negative effect on broiler production parameters and carcass quality characteristics.

Keywords: Broilers, diatomaceous earth, production & carcass characteristics.

DECLARATION

I, **Asipe Sikona Motolwana** declare that this dissertation: **Effect of dietary inclusion level of diatomaceous earth on production and carcass characteristics of broilers** submitted to the Central University of Technology, Free State in fulfilment of the requirements for the degree Magister Technologiae: Agriculture is my own independent work and I have not previously submitted this dissertation to obtain a qualification at another university. I further disclaim the copyright of this dissertation in favour of the Central University of Technology, Free State.

Signature:………………………. **Date:……………………..**

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LIST OF ABBREVIATIONS AND ACRONYMS

°C : Degrees Celsius

µ : Micron

ADFI	: Average daily feed intake
ADG	: Average daily gain
AGP	: Antibiotic growth promoters
BW	: Body weight
DAFF	: Department of Agriculture, Forestry and Fisheries
DE	: Diatomaceous earth
PEF	: Performance efficiency factor
EU	: European Union
FCR	: Feed conversion ratio
g	: Gram
GRAS	: Generally recognised as safe
EPA	: Environmental protection agency
HSD	: Honest significant difference
IDPA	: International Diatomite Produces Association
kg	: Kilograms
mg	: Milligrams
mm	: Millimetres
pH	: Potential of hydrogen
ppm	: Parts per million
SAS	: Statistical analysis software
SGS	: Societe Generale de Surveillance
SIO_2	: Silicon oxide
USA	: United States of America
NH_3	: Ammonia

CHAPTER 1

GENERAL INTRODUCTION

1.1 Introduction

The poultry industry has in recent years occupied a leading role among agricultural industries within South Africa, with poultry meat and eggs serving as an important source of high quality animal protein (Zarin *et al*., 2007). The main role of broiler production is to improve the profitability of broiler meat production by minimizing feed and/or input costs. Therefore, success in poultry meat production has been related to the improvement in growth performance and carcass yield, by means of improving breast meat yield and reducing abdominal fat (Zerehdaran *et al*., 2004).

The sub-therapeutic use of antibiotics in poultry feed has become more undesirable due to traces of chemical residues being apparent in meat and meat products, coupled with the increasing development of antibiotic-resistant bacterial population in humans (Adebiyi *et al*., 2009). In recent years, most European Union (EU) countries have banned the use of antibiotics as a growth promoting agent, forcing many feed producers to undergo voluntary withdrawal of these additives, resulting in a steady increase of organically produced eggs and poultry meat (Grashorn, 2010). Graham *et al*. (2007) further suggested that the production costs could be reduced with the exclusion of antibiotics in broiler feed.

However, free range poultry are more prone to parasitic infestations than any other commercially produced poultry (Bennett *et al.,* 2011). Parasitic infestation in a production unit can cause health implications such as impaired weight gain and a decrease in egg production as well as an increased mortality rate. Graham *et al.* (2007) and Bennett *et al*. (2011) suggested that there is a need for an effective and safe method for the treatment of parasites to improve organic poultry production.

Herbs, fossil shell flour and spices have received an increasing attention as possible growth promoter additive references (EL Tazi *et al*., 2014). Macy (2000) proposed the addition of diatomaceous earth in the diets to control parasites and subsequently improve certain production factors, such as the average daily gain (ADG) and feed conversion ratio (FCR) of productive chickens.

Diatomaceous earth (DE) is obtained from geological deposits of diatomite, which are fossilized sedimentary layers of microscopic algae called diatoms. DE is made up mainly of silicon oxide (SiO_2) and functions as an insecticide through physical mechanization (Fields *et al.*, 2002).

Dawson (2004), as well as Maurer *et al.* (2009), stated that the use of DE on tree swallows has shown to control ecto-parasite infestation and reduce poultry red mite (*Dermanyssus gallinae*) survivability *in vitro*. Bennett *et al*. (2011) also suggested that feeding supplementary DE to laying hens can improve feed conversion efficiency and egg production. Similar findings were reported by Bernard *et al*. (2009) where he observed an improvement in the weight gain of parasite infested goats treated with DE.

1.2 Problem statement

The use of antibiotic growth promoters (AGP's) in animal feed has a negative effect in relation to the formation of chemical residues in tissue, as well as the development of resistance in microorganism (Markovic *et al.,* 2009). Moreover, this has caused consumers to become more concerned about the safety and ethical production of food, which has led to an increasing demand for organically produced poultry meat and eggs (Berg, 2001; Patterson *et al.,* 2001; Kouba, 2003; Oberholtzer *et al.,* 2006; Bejaei and Cheng, 2010).

However, the discredited use of AGP's in poultry feed by consumer associations as well as by some scientists have consequently forced many feed industries to explore alternatives for AGP's (Alcicek *et al.,* 2003; Graham *et al*., 2007).

The primary goal of broiler production is to maximize profitability from poultry meat production (Zerehdaran *et al*., 2004). Waller (2007) suggested a two-way approach of improving profit margins; firstly, by increasing levels of production and secondly, by reducing the variable costs. Feed cost in a broiler unit is the most outstanding variable cost, accounting for more than 70% of the total production costs (Adeyemo, 2013). Graham *et al*. (2007) reported that production costs can be reduced by substituting growth promoters with organic feed sources without compromising the nutritional value of the diet.

Diatomaceous earth is often promoted by testimonies and product claims to be effective in the improvement of certain productive traits and safe for livestock use, but little scientific research has been performed to evaluate its efficacy (Bennett *et al.,* 2011).

The questions that arise from various scientific reports are: (i) whether supplementary diatomaceous earth (DE) has an effect on improving certain productive traits and (ii) whether supplementary DE improves carcass characteristics of broilers.

1.3 Motivation

The progressive use of AGP's in poultry diets has been claimed to induce some resistance in human bacterial strains (Grashorn, 2010). This, however, motivated new research for AGP alternatives, but also an emerging interest for substances already known but not yet extensively used as a feed additive for poultry (Mallet *et al.,* 2005).

Diatomaceous earth is a natural substance that has been tested as an alternative to antibiotics and other feed additives (Mclean *et al.,* 2005). Furthermore, this natural substance has shown some potential for parasitic control and boosting feed conversion while promoting growth, but little research has been done in poultry (Adeyemo, 2013), with special reference to broilers.

1.4 Objectives

Main objectives

- Determining the effect of dietary inclusion level of diatomaceous earth on production and carcass characteristics of broilers.

Specific objectives

The specific objectives are to:

- Investigate the effects of dietary inclusion level of diatomaceous earth on the average daily gain (ADG), feed conversion ratio (FCR) and the performance efficiency factor (PEF) of broilers.
- Determine the effects of dietary inclusion levels of diatomaceous earth on carcass characteristics.

- Evaluate the effect of dietary inclusion levels of diatomaceous earth on litter quality of broilers.

1.5 Hypotheses

Supplementary DE in broiler diets is estimated to have a positive effect on certain productive traits (ADG, FCR and PEF) of broilers.

Supplementary DE in broiler diets is estimated to improve the overall carcass characteristics of broilers.

Supplementary DE in broiler diets is expected to have a significant positive effect on decreasing the moisture content of litter.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Diatomaceous earth (DE) is described as a powdery, non-metallic mineral which occurs naturally from a silicon rich sedimentary rock made up from remains of fossilized diatoms, which is a hard shelled plant alga that was deposited on earth from desiccated rivers and seas (IDPA, 2013). More than a thousand of these microscopic algae have been recognized to possess its own distinct shape and characteristics, with sizes ranging between 5 µ to over 100 µ (Fields *et al*., 2002).

Diatomite deposits are often categorized based on their origin of either fresh or salt water sources. Both the chemical composition and the physical structure of diatomite make it of great commercial value for a wide range of functions such as filter aids, functional filters, a carrier for active ingredients, diluents and aggregates (Insung, 1999).

Many marine animals utilize living diatoms in bodies of water as a source of food (IDPA, 2013). Furthermore, these diatoms are a major source of atmospheric oxygen which is produced by photosynthesis. Over millions of years, diatomite remained settled, forming deposits on ocean and river floors, while some of this DE has risen over the years to become part of our present land-mass (Quarles, 1992).

Diatomaceous earth is found all around the world with the USA and China serving as the biggest producers (Korunic, 1998). According to Koster (2013) DE has been used as an organic product for animal health and nutrition. Korunic (1998) also reported that DE from different geographical areas exhibit differences in efficacy due to the differences in physiological properties and diatom species.

In South Africa, DE is mined from seven different fresh water sources in the Olifantshoek area by Diatoms SA (Mvumi *et al*., 2006). Typically, South African DE consist of 3% magnesium, 33% silicon, 19% calcium, 5% sodium, 2% iron and numerous other minerals including titanium, boron, manganese, copper and zirconium (Mvumi *et al*., 2006). The DE from Olifantshoek has been registered under the South African Farm Feed and Fertilizer Act (36/1947), and it is also Societe Generale de Surveillance (SGS), European Union (EU), Generally recognised as safe (GRAS) and Environmental protection agency (EPA) approved (Koster, 2013).

To ensure a high quality end-product, processers have to ensure that the mined DE rock is of the highest purity and free from other heavy impurities (Koster, 2013). A homogenous DE product is in great demand, since food and feed processors prefer a DE product that is intact without broken frustules. Only food graded DE from natural fresh water with a pH of ≥7 are recommended for safe use.

Chalk-like DE is porous and easily crumbled into soft fine white to off-white powder due to its light weight. Furthermore, the DE powder has been closely linked to pumice powder because of its abrasive feel, constituting of particle sizes ranging from less than 1 µ to more than 1 mm (IDPA, 2013).

Quarles (1992) suggested that amorphous silica is more soluble than crystalline silica with less health hazards. DE popularity has grown over the years and it has been used by different industries for cat litter, water filters, food preservatives and in crop production as an insect eradicator (IDPA, 2013). Due to DE's high heat resistance, it is used as a thermal insulator (Koster, 2013), as well as a component of dynamite.

Interestingly, DE has shown to be non-toxic for mammals and is also presumed to be non-toxic for avian species (Quarles, 1992). Dawson (2004) reported that DE does not only reduce insect pests in stored grains, but also serves as an effective ecto-parasite remedy for avian species. However, Koster (2013) reported that although DE reduces insect pests in grains, it also has certain disadvantages such as: (i) reduction in flow characteristics of grain, (ii) reduction of the bulk density of grain, (iii) ineffective in some situations, and (iv) associated with discomfort for humans due to some air-borne dust and health concerns caused by the usage of crystalline silica.

Diatomaceous earth sticks to the surface of the kernel and increases friction between grain kernels. This causes increased angles of repose and decrease bulk density. Diatomaceous earth at 500 ppm, decreases bulk density by about 6 kg/100 litres in wheat, barley, oats, rye and maize. Unfortunately, the DE that are the most effective insecticides are also the ones that reduce the bulk densities the most. As desiccation is the major mode of action, DE controls insects better in dry grain than in moist grain. Unlike a fumigant, it will not control the immature stages of insects that remain within the grain kernel for an example *Sitophilus spp (*Fields, 2000).

2.2 Mining and processing of diatomaceous earth

During the early development of DE, it was processed almost exclusively by hand by means of excavation from river/lake beds as blocks, dried and shipped. Currently, DE is mined by open-pit quarrying techniques that require heavy duty machinery. According to Dolley (2000) there are three different processes used to produce a large variety of DE products namely natural grade, calcinated grade and flux-calcined grade;

2.2.1 Natural grade

Crude DE is milled and dried at temperatures between 70° and 430°C. The removal of extraneous matter is done using a technique called classification and this process produces a variety of different particle sizes (Bolm *et al*., 2003). These natural powders, consisting primarily of amorphous silica, are generally white in colour.

2.2.2 Calcinated grade

Natural material is used to produce this product by calcination or sintering, at higher temperatures usually in excess of 900℃ in a rotary kiln (IDPA, 2013). During calcination any organics and volatiles are removed and the colour of DE typically changes from off-white to tan or pink. After calcination the diatomite is further processed into products with selected particle sizes that can include filter acids, multifunctional filters and aggregates (Dolley, 2000).

2.2.3 Flux-calcined grade

This product can also be produced from natural materials by calcining in a rotary kiln. High temperatures in excess of 900℃ are used in the presence of a flux such as sodium carbonate. During flux-calcination the diatoms further increase in particle size through agglomeration and in many instances become bright white in colour (Bolm *et al*., 2003). Further milling and air separation control the final particle size distribution to produce filter acids of relatively high permeability and fine white multi-functional filters (IDPA, 2013).

2.3 Uses of diatomaceous earth in the agricultural industry

In the grain industry, DE has taken a position of being the most used organic insecticide as the grain industry needs to reduce its reliance on synthetic insecticides. The main advantage of DE is that it is non-toxic to mammals (Fields *et al.,* 2002). Furthermore, Athanassiou *et al*. (2009) reported that DE has proven to be effective against a wide range of insects, such as beetles, moths and mites within stored food products (Palyvos *et al.,* 2006).

Athanassiou (2004) reported that larvae of the confused flour beetle (*Tribolium confusum*) have a higher mortality rate than the adults after being exposed to DE on wheat or flour. Currently DE is applied at approximately 100 mg/kg in wheat during storage (Wakil *et al.,* 2005).

Inclusion level of DE above 400 mg/kg causes a reduction in bulk density and a significant decrease in the flow characteristics of grain (Wakil *et al*., 2005). The physical and chemical properties of DE such as the percentage of amorphous silicon dioxide, pH, porosity and active surface, absorption capacity, particle size distribution and the adherence of DE particles to kernels are the critical factors affecting their insecticidal action. Korunic *et al*. (2009) reported that four distinct uses for DE are namely: (i) insect and parasite control, (ii) mineralization, (iii) deodorization/absorption and (iv) grain protection.

2.3.1 Insect and parasite control

Diatomaceous earth has been reported to be an effective organic deworming remedy for commercial livestock (Sooby *et al.,* 2007; Bernard *et al.,* 2009). Quarles (1992) and McLean *et al*. (2005) suggested that DE controls parasites due to its abrasive action of the powdery pierces or by scratching the outer protective layer of invertebrate, including internal parasites, resulting in death by dehydration. Diatomaceous earth could be fed on a continuous basis to large livestock for internal parasite control (Koster, 2013).

2.3.2 Mineralization

Diatomaceous earth consists of mainly silicon in the form of SiO_2. Silicon is known for its importance for bone and connective tissue health. In humans and animals, higher concentrations of silicon are often associated with bone and connective tissue, compared to non-connective soft tissue (Jugdaohsingh *et al*., 2015). Nielsen (2014) suggested that silicon is an important trace element in mammalian diets for the normal growth and functioning of bones and connective tissue.

Heinegard and Oldberg (1989), suggested that silicon deficiency affects the connective tissue metabolism, as this element influences the biosynthesis of glycosaminoglycans and collagen, which are necessary for organic bone matrix formation. Birchall (1995) and Jugdaohsingh *et al*. (2000) suggested that silicon has a unique affinity for aluminium (Al), preventing its absorption in animals. Reffitt *et al*. (2003) and Domingo *et al*. (2010) postulated that silicon may have a binding effect on toxic Al ions that may have a detrimental effect on bone health.

As bone mineralization progresses, the silicon and calcium contents rises congruently in the osteoid tissue. Nielsen (1991) reported that as mineralization stages advance, the silicon concentration in the connective tissue decreases.

According to Bennett *et al*. (2011) DE inclusion in layer diets improved their body weight and egg production up to 32 days in their production cycle. Furthermore, Koster (2013) elaborated that this could probably be attributed to various factors such as the reduction in parasite population which results in decrease stress on the animal and increased food assimilation, or maybe the mineral content of DE plays some role in this as well.

2.3.3 Deodorization/absorption

Deodorization/absorption is one of the major benefits of DE. Koster (2013) reported that this function is promoted as the undigested DE passes with the manure through the large intestine. Furthermore, a reduction in fly eggs from hatching has been observed in manure of DE fed livestock. Koster (2013) further stated that DE binds NH_3 effectively, therefore it could be used as an odour reducer in most intensive farming operations.

2.4 Factors affecting broiler performance

2.4.1 Temperature

Temperature is one of the most important non-dietary factors influencing feed intake and growth performance of poultry. High temperatures are also known to cause discomfort for birds, reduce feed intake especially during the post-brooding stage and affects overall broiler performance (Daghir, 2008). High temperatures do not only affect feed intake and FCR, but also effects carcass quality and meat yield (Aksit *et al.,* 2006; Bianchi *et al.,* 2007).

Broilers perform optimally under minimal variation in temperature during a 24 hour period, while heating is imperative both for growth and economical purposes in cooler areas. Under cool environmental temperatures, birds tend to eat more, contributing to a poorer FCR due to the increase in maintenance energy requirements. Under these conditions, much of the calories obtained from the feed are used to regulate body temperature while only the remainder is utilized for production purposes. Ambient environmental temperature allows broilers to utilize nutrients for growth rather than using them for temperature regulation (Nembilwi, 2002).

2.4.2 Photoperiod

Photoperiod within a broiler production system is one of the main prerequisites. Lighting in a broiler facility renders a powerful exogenous factor used to control many physiological and behavioural processes. Furthermore, light allows birds to establish rhythmicity and synchronize many essential functions, including body temperature and various metabolic steps that facilitate feeding and digestion (Olanrewaju *et al.,* 2006).

Light intensity, colour and photoperiodic regime can affect the physical activity of broiler birds (Lewis & Morris, 1998). Wilson *et al*. (1984), Blair *et al*. (1993) and Apeldoorn *et al*. (1999) further explained that feed utilization could be improved by altering lighting schedule in terms of reducing the hours of light or developing intermittent light schedules. There are at least four important aspects that relates to the photoperiod used during the rearing of broilers (Olanrewaju *et al.,* 2006):

- Wavelength
- Intensity
- Duration
- Distribution

Photoperiod regimes have a significant influence on the rate of growth and consequently the final body weight of broilers. Buyse & Decuypere (1988) observed a lower cumulative feed intake, followed by a significantly improved feed conversion ratio on birds raised under an intermittent lighting schedule (1L:23D) compared with those under continuous lighting schedule (23L:1D) from 8 to 49 days. Classen (2004) further reported that a short photoperiod of 12 hours light and 12 hours darkness (12L:12D) reduces the feed intake and overall growth performance of broilers. Charles *et al.* (1992) and Kuhn *et al*. (1996) reported that the use of an intermittent photoperiod regime (1L:3D) on male broiler birds improved their growth rate and increased their plasma growth hormone levels and testosterone concentrations, compared to a continuous lighting (24L:0D) regime.

Table 2.1 illustrates broiler performance kept under two photo-period regimes (Esmail, 2013). The study reveals that birds under an intermittent photoperiod regime had a low feed intake, but it resulted in a better FCR and body weight gain (Esmail, 2013). This improvement is achieved by resting the birds during a 3 hour session of darkness, causing maintenance energy requirements to be lowered thus allowing more energy to be used for growth.

Table 2.1 Comparison of broiler performance under two lighting system.

Parameters	**Continuous photo-period**	**Intermittent photo-period**
Feed intake (g/b/d)	3.72	3.69
Weight at 7weeks (g/b)	1.90	1.95
FCR (g/g)	1.96	1.90

Colour of light is also one of the major aspects in broiler production. Olanrewaju *et al.* (2006) postulated that colour is dictated by its wavelength and exerts variable influences on broiler production. Esmail (2013) suggested that the feed consumption of broilers can be improved under white light due to the feed texture, which is better identified under this colour of light.

Within the broiler industry, certain light colours are used to alleviate production problems namely; (i) blue light has a calming effect on birds, (ii) blue-green light promotes growth while (iii) orange-red light stimulates reproduction (Rozenboim *et al*., 1999a, b; 2004).

2.4.3 Nutritional factors

2.4.3.1 Physical form of food

The physical form of the feed is a crucial factor that should be considered for meat yield in broiler production. Chehraghi *et al.* (2013) reported that different feed forms (mash, crumble and pellet) directly influence the production performance of broiler birds.

Preston *et al*. (2000) suggested that birds fed a mash diet between 3-6 weeks of age have the lowest feed intake. Dozier *et al*. (2010) also observed a poor growth performance of birds fed on a mash diet. Pelleting is the process of mechanically pressing mash into hard dry pellets. It is a compact complete feed that is pressed in pellets of approximately 3 mm in diameter and 5 to 6 mm in length.

The greatest advantage of using pellets instead of mash or crumbles is that there is little to no wastage. Nir *et al.* (1995) and Asha Rajini *et al.* (1998a;1998b) reported an improved feed efficiency derived from pellets when fed to broilers up to the age of 6 weeks. Also, Dozier *et al.* (2010) reported that birds fed a pelleted diet have an increased FCR, coupled with an improved growth performance. This is suggested to be caused by the less time being spent at the feeder to consume feed, translating into a reduction of energy spent on the feeding process.

2.4.3.2 Diet dilution

Diet dilution has been used as an alternative method of nutrient restriction due to its advantages of attaining a more consistent growth pattern within a broiler flock. Leeson *et al*. (1991) as well as Jones and Farrell (1992) observed a complete compensatory growth in broiler birds at 42 days of age that were fed a diet diluted with 65% rice hulls during the early growth stages. Moreover, Cabel and Waldroup (1990) also observed compensatory growth at 49 days of age when the broiler diet was diluted with sand from 5 to 11 days of age.

On the contrary, Zubair and Leeson (1994) reported that birds fed a 50% diet diluted with oats hulls for 6 days during the brooding stage showed no significant difference in body weight at the end of 42 days. Furthermore, no significant differences were observed at 49 days of age on body weight and breast meat yield in birds fed a finisher diet diluted up to 50% with a 50:50 mixture of sand and oats hulls from 35 to 49 days of age (Leeson *et al*., 1992).

2.4.3.3 Nutritional value of diets

Broilers require 220 g, 200 g and 180 g crude protein per kg feed during the brooding, grower and finisher period respectively, and 3200 kcal ME/kg feed for optimal growth (NRC, 1994). When broilers are fed diets with a low nutritional value they tend to increase their feed intake in an attempt to maintain nutrient intake levels (Leeson & Summers, 1997). Yolcin *et al*. (1990) and Holsheimer & Veerkamp (1992) reported that high energy diets significantly increased carcass weight and abdominal fat of broiler birds.

Plavnik and Hurwitz (1990) observed that broilers fed *ad libitum* with a diet containing 9% crude protein from 8 to 14 days of age markedly reduced their feed intake and weight gain by 63% respectively and did not recover the body weight as measured at 56 days of age. Smith (2006) further suggested that higher live weight and carcass meat yield in broilers may be achieved by feeding the birds a higher nutrient density diet (21.2 to 25.9% crude protein, 13.9 to 14.3 MJ ME/kg).

2.4.4 Genes, sex and hormones

The response of birds to various feeding programs is influenced by the genotype and sex of the bird. Gous *et al*. (1999) confirmed that the genetic potential of broilers influences the growth potential of the bird, as it affects its nutritional requirement. Havenstein *et al*. (1994) suggested that the genetic potential, rather than the nutritional requirement, has a greater influence on the body composition of broiler birds. Hence, most of the discrepancies in the results concerning the response of broiler birds subjected to various feeding programs, has been credited to differences in genetics of birds used (Fontana *et al*., 1992; Schiedeler & Baughman, 1993).

Bird sex has also been considered to have an impact on the overall bird performance. Zubair and Leeson (1996) reported that the differences in responses between sexes is likely the result of the higher innate growth rate of male birds in comparison to female chickens. Han & Baker (1994) and Nahashon *et al*. (2004) further suggested that male broiler birds have a higher feed intake, growth rate and leaner body composition than female birds. On the contrary, Young *et al.* (2001) observed that female birds yielded larger proportions of the forequarter, breast and filets than male birds at slaughter.

In poultry, triiodothyronine (T_3) and thyroxin (T_4) are the major hormones required for growth and development of organisms (Scanes, 2011). Stojevic *et al.* (2000) reported that T_3 and T_4 are secreted in the endocrine organ found in all vertebrates called the thyroid gland. Furthermore, Stojevic *et al*. (2000) observed that high blood concentration levels of T_3 induces feed intake, compared to low blood T_3 circulation during fasting. Moreover, these thyroid hormones are primarily involved in the production of energy by inducing the metabolic rate of the bird.

2.4.5 Medicaments

High genetic potential, balanced nutrition and health maintenance are paramount factors for a successful poultry production system. Recently, there is an increasing demand to produce poultry meat and eggs without the use of antibiotics in poultry diets due to the residuals in meat products (Mehala % Moorthy, 2008). Supplementation of poultry diets with natural components as antibiotic substitutes has been adopted by many poultry producers (EL Tazi *et al*., 2014). Herbs, spices and humates have received increasing attention as possible growth promoters (Al-Kassie & Witwit, 2010). Mehala & Moorthy (2008) suggested that *Aloe vera* and *Curcuma longa* herbs improve feed intake of broiler birds. Furthermore, herbs such as *Hoodia gordonii* is suggested to reduce fat pad weight by 40% when supplemented at 300 mg daily (Mohlapo *et al*., 2009).

Garlic and black pepper are well known as spices and herbal medicine for the prevention and treatment of a variety of diseases (Hassan *et al*., 2007; Javandel *et al*., 2008). Tekeli *et al*. (2006) and Demir *et al*. (2003) reported that garlic can improve productive performance of broiler chicks. Furthermore, Elagib *et al*. (2013) suggested that 3% addition of garlic in broiler diets improves growth performance of broiler chicks. A study on the effect of black pepper as a natural additive in broiler diets showed a significant improvement in broiler weight gain, FCR and dressing percentage (EL Tazi *et al*., 2014). Moreover, Al-Kassie *et al*. (2012) also observed similar findings that black pepper inclusion in broiler diets significantly improved body weight gain, feed consumption and FCR. This shows that natural additives have a potential to partially replace antibiotics as feed additives.

Humates (which are naturally occurring sources of humic and fulvic acid), are also popular natural feed additives, as they form part of fertilizers and are derived from decomposed plant material (Karaoglu *et al*., 2004). Humates are suggested to improve growth performance, FCR and reduces mortality rate (Eren *et al*., 2000; Yoruk *et al*., 2004).

2.4.6 Housing

An ideal housing system is essential for the comfort and health of the birds. Scanes *et al.* (2004) reported that housing allows convenience and easy management at reasonable costs. Housing and ventilation depends mainly on the surrounding climatic condition, but an effective ventilation system is needed for the removal of excess heat and moisture, to provide oxygen and to improve air quality and circulation (Ross Breeders, 2009). The main contaminants of air within broiler houses are dust, ammonia, carbon dioxide, carbon monoxide and excess water vapour. Buildup of ammonia results in retarded growth and partially reduces body weight gain of broilers (Nembilwi, 2002).

2.4.7 Ventilation

Ventilation in broiler houses is paramount to improve growth performance and overall health of the birds. A constant and uniform supply of good quality air at bird level is critically important (Bucklin *et al*., 2009). Fairchild *et al.* (2012) suggested that fresh clean air is required at all growth stages to allow birds to remain in good health and achieve their full production potential. Ventilation also assists with temperature regulation in relation with the comfort zone of birds (Tabler, 2013). There are two main types of ventilation systems namely: (i) natural and (ii) mechanical ventilation (Fairchild *et al.,* 2012).

Natural ventilation could be defined as basically an open-side house with curtain flaps or doors. It involves “opening up” or “raising” the sides of the house to allow air to flow into and through the house. When the side curtains are opened, they allow a large volume of outside air through the house depending on the environmental conditions such as the wind speed, equalising the inside and outside conditions (Fairchild *et al.,* 2012). This type of system is mostly ideal when outside temperature is close to the target house temperature (Donald, 2009).

Mechanical ventilation is the most popular ventilation system used by most modern broiler producers (Bucklin *et al.,* 2009). It has a better overall air exchange rate and airflow pattern that provides a more uniform condition throughout the house. This type of ventilation system uses electric exhaust fans to draw air out of the house and creates a low pressure vacuum within the house, also called “negative pressure” ventilation (Ross Breeders, 2009). Fresh air from the environment will then be drawn into the house, depending on the size of the inlet openings and the extraction fan speed.

2.4.8 Stocking rate

In order for broilers to achieve their optimal growth potential, they must be provided with optimal environmental conditions (Smith, 2006). High stocking rates (30 birds/m^2) restrict access to feed, increases heat stress, increase ammonia level, reduce liveability and in most cases decrease carcass quality (Feddes *et al.,* 2002). Furthermore, broilers housed at high stocking densities usually have a lower body weight at the age of seven weeks (Nembilwi, 2002).

In high stocking density houses, the airflow is reduced and this further reduces dissipation of body heat to the air (Feddes *et al.*, 2002). Guardia *et al.* (2011) reported a linear reduction in body weight, feed intake and FCR in broiler houses with a stocking density of 12-17 birds/m^2. Feeding space and drinker availability must also be adjusted in relation with the stocking density of the birds (Smith, 2006).

Floor area needed for each bird is dependent upon the following aspects as supported by Ross Breeders (2009):

- Target live weight and age of slaughter.
- Climate and season.
- Type and system of housing and equipment, particularly ventilation.
- Local legislation.
- Quality assurance certificate requirements.

2.4.9 Parasites

A parasite is an organism that lives in or on another organism (referred to as the host) and gains an advantage at the expense of the host organism. Worms and protozoa are two types of common parasites that affect poultry (Scanes *et al.,* 2004).

Usually, low levels of infestation do not cause a problem and can be left untreated. Signs of parasite infestation may include thriftiness, poor growth and FCR, decreased egg production, and in severe cases, death (Nnandi & George, 2010). Furthermore, parasites can make a flock more susceptible to bacterial or viral diseases, or worsen a current disease outbreak (Jacob, 2015).

2.4.10 Biosecurity

Biosecurity in broiler production is one of the most important aspects that could render a business unprofitable. A good biosecurity programme is essential to limit the occurrence of diseases and maintain a healthy flock (Ross Breeders, 2009; DAFF, 2013). Regular staff training is essential to ensure this. When developing a biosecurity programme, three components should be considered (FSA, 2006):

- Location: the farm should be located so that they are isolated from other poultry and livestock. A single-aged site is preferred so that the recycling pathogens and live vaccine strains are limited.
- Farm design: a barrier is necessary to prevent unauthorized access. Housing should be designed to minimize traffic flow, facilitate cleaning and disinfection and be bird and rodent proof.

- Operational procedures: procedures must control the movement of people, feed, equipment and animals on the farm to prevent the introduction and spread of diseases. Routine procedures may have to be modified in the event of a change in disease status.

2.4.11 General health management

In a broiler production system, good health management practices are imperative (DAFF, 2013). Therefore, for an effective poultry health management programme to be achieved, it must aim at: (i) preventing the onset of disease or parasites, (ii) early detection of disease infestation and (iii) treating all birds that are infested with diseases or parasites to limit the spreading thereof to other birds in the house (Nnandi & George, 2010). Furthermore, a poor health management programme implicates production and flock management, including growth rate, FCR, carcass condemnation, liveability and processing traits (Ross Breeders, 2009).

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CHAPTER 3

MATERIALS AND METHODS

3.1 Location

The study was conducted at the broiler experimental facilities of the University of the Free State (UFS) within a six-week period following the approval by the Animal Ethics Committee of the University of the Free State (Experiment No. 04/2014).

3.2 Experimental design and dietary treatments

A total of 750 day-old Arbor Acre (as hatched) broilers were obtained from a commercial hatchery close to Bloemfontein and randomly allocated to the five dietary treatments (n=150/treatment). All birds were housed in a semi-environmental controlled environmental building, which was equipped with temperature and photo-periodic regulating equipment. Within the building, 30 floor pens (2.2 m^2/pen) were used for the rearing of each of the replicate groups of the birds (5 treatments x 6 replicates/treatment/25 birds/replica), according to the procedures of Adedeji *et al.* (2014) and Sadeghi *et al.* (2014). All the birds were weighed as a replicate group on arrival (D0) and randomly allocated to the various floor pens, resulting in a population density of 11 birds/m^2 (Mallet *et al.*, 2005).

Pine wood shavings were used as deep litter bedding and each pen was provided with a single tube feeder, "bell-shaped" water-drinker and an infra-red lamp for additional spot heating (Mallet *et al.*, 2005). During the first 7 days of the study, smaller "chick" feeder trays and drinking fonts were used to supply feed and water to the young birds (Zerehdaran *et al.*, 2004). Feed and water provision was on an *ad libitum* basis, throughout the experimental period (Chehraghi *et al.*, 2013).

A photoperiod of 23 hr light and 1 hr darkness (23L:1D) was implemented for the first 5 days of the experiment. Thereafter, the schedule was reduced to 18 hr light and 6 hr darkness (18H:6D) for the remaining 37 days of the study period. Brooding temperature was gradually decreased from 33 ˚C (D0) to 24 ˚C at 21 days of age.

A standard commercial broiler diet consisting of a three-phase feeding regime (starter, grower, and finisher) was used during the experimental period of 42 days. The feeding regime of the three dietary phases was as follows (McGroven *et al.*, 1999):

1. Starter: Day 0-16
2. Grower: Day 17- 35
3. Finisher: Day 36- 42

Table 3.1 Mean physical composition (%) of the three experimental diet (as is basis).

Ingredients	Starter	Grower	Finisher
Yellow Maize	59.05	62.61	68.28
Prime Gluten 60	0.00	0.00	0.00
Wheat bran	4.00	1.90	0.00
Soya-bean meal	29.30	27.20	19.30
Sunflower oilcake	4.00	5.00	5.90
Limestone powder	1.30	1.20	1.20
MCP	1.25	1011	0.96
Salt	0.42	0.43	0.36
Other	0.67	0.55	0.79

During this study, the supplementary dietary inclusion of diatomaceous earth (DE) was implemented only during the grower (D17-35) and finisher (D36-42) phases (Bennett *et al*., 2011). In total, birds were subjected to supplemental dietary DE for a maximum period of 25 days before termination of the study (D42). Dietary inclusion of DE occurred with 0.5% increments as follows:

Treatment 1: control diet (0% DE)

Treatment 2: control diet + 0.5% DE

Treatment 3: control diet + 1.0% DE

Treatment 4: control diet + 1.5% DE

Treatment 5: control diet + 2.0% DE

Table 3.2 Calculated mean chemical composition (g/kg DM) of the three experimental diet

Composition	Starter	Grower	Finisher
AME[1] (MJ/kg DM)	12.13	12.38	13.08
Protein	208.12	197.89	188.06
Fat	3.02	3.04	3.02
ASH	5.83	5.43	4.89
NDF[2]	10.49	9.51	9.07
ADF[3]	3.68	3.71	3.62
Ca	9.53	8.89	8.45
P	6.32	5.86	5.32
Mg	1.95	1.86	1.66
K	7.82	7.41	6.01
Na	2.00	1.90	1.80
Cl	3.01	3.00	3.00
Arginine	13.98	13.34	11.56
Isoleucine	8.76	8.34	7.71
Lysine	11.08	10.40	9.72
Methionine	4.51	3.87	3.82
Threonine	7.63	7.29	6.73
Tryptophane	2.56	2.43	2.05
Methionine & Cystine	8.37	7.57	7.43

1 Apparent metabolizable energy.
2 Neutral detergent fibre.
3 Acid detergent fibre.

Figure 3.1 Mixing of different DE experimental diets using a small paddle-type feed mixer.

3.3 Data collection

Body weight and feed intake of each replica group were determined weekly in the following sequence: Day 0, 7, 14, 17, 21, 28, 35 and 42 (Mallet *et al.*, 2005). Weekly mortalities were recorded and expressed as a percentage and considered when calculating mean feed intake and body weight gain of each replicate (Benabdeljelil & Ayachi, 1996). The feed conversion ratio was calculated on a weekly basis for each of the replicate pens and expressed on a gram feed intake/ gram body weight gain basis (g/g) (Mallet *et al.*, 2005). Ambient temperature (minimum & maximum) was recorded on a daily basis at 08H00.

Figure 3.2 Weekly determination of body weight (g) and feed intake (g) of birds.

Litter samples were taken on a weekly basis at Day 0, 7, 14, 21, 28, 35 and 42 days of age according to the sampling method described by McGrath *et al*. (2005), to determine the dry matter (DM) content thereof. Samples were collected at five different locations from each pen (2.5 cm diameter and 5 cm in depth). Encrusted litter was broken into smaller pieces after sampling and thoroughly homogenized with the rest of the samples from the specific pen to obtain a representational litter sample for the entire pen.

A sub-sample (100 g) was taken from each pen's representative litter samples. After weighing the sub-samples, they were individually marked and placed into a pre-heated (100 °C) oven for a 24 hour duration to determine moisture loss in the litter (Benabdeljelil & Ayachi, 1996; Tatar *et al.*, 2012).

On completion of the study (D42), 24 birds per treatment (n=12 male & n=12 female) were individually weighed, marked with a leg tag and fasted for 12 hours before slaughtering at a registered small scale poultry abattoir. After slaughtering, individual carcasses were weighted (wet weight) and expressed as a percentage to live weight (Zerehdaran *et al.*, 2004; Laudadio & Tufarelli, 2010). Carcasses were individually cut into eight (8) piece portions (breast, drumstick, thigh and wing X 2) to determine the meat yield of each specific portion. Furthermore, internal organs such as the hearts, livers and gizzards were individually eviscerated and weighed for further calculations using the procedures of Adedeji *et al.* (2014).

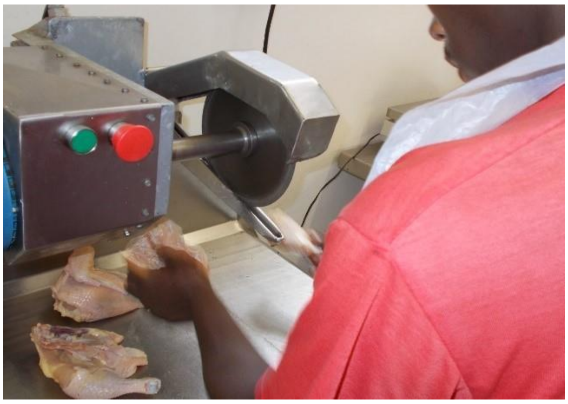

Figure 3.3 Cutting carcasses into eight piece portions for weighing.

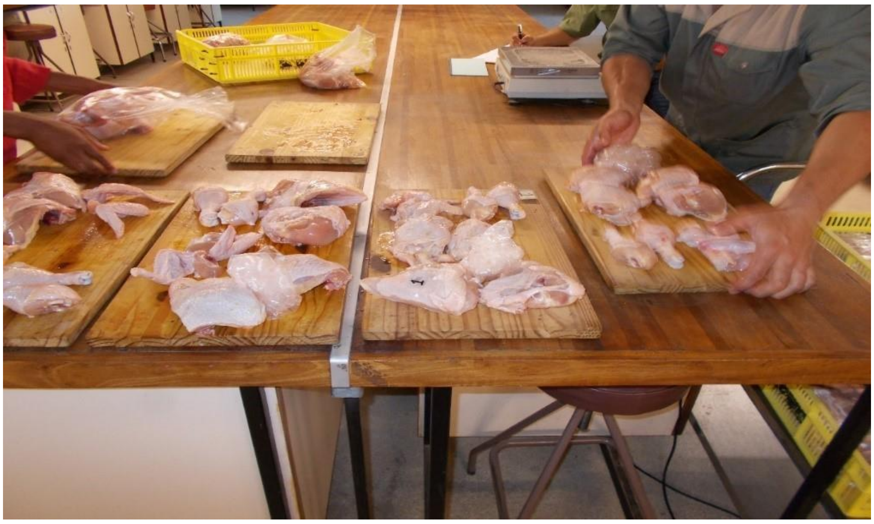

Figure 3.4 Weighing of different portions.

3.4 Performance efficiency factor

The performance efficiency factor (PEF) of the experimental broilers were calculated using the following formulae (Moneim *et al.*, 2014):

$$PEF = \frac{\text{Live weight (kg) x Liveability (\%)}}{\text{Age at depletion x FCR}} \times \frac{100}{1}$$

At the end of experimental period (D42), the performance efficiency factor (PEF) was calculated, based on the age of the broilers at slaughter (days), the average live weight (kg/bird), liveability (%) and FCR (g/g) of the birds. The advantage of using the PEF is that all factors mentioned above are considered simultaneously and it gives a reasonable idea of the overall efficiency.

3.5 Statistical analysis

To determine the effect of the dietary DE inclusion level on the production performance and carcass composition data of individual collection weeks was pooled and analyzed as a mean. All the data were analyzed (P<0.05) using a fully randomized one-way ANOVA procedure of the SAS programme (SAS, 2014). Tukey Kramer's standardized range (HSD) test was used to illustrate differences between treatment means as identified by the analysis of variance procedure (Morrison *et al.,* 2013).

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CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 Introduction

The demand for organically produced animal products, including organic poultry eggs and meat has increased immensely due to consumers being increasingly concerned with the safety and ethical production of their food (Bennett *et al.,* 2011). This has led to an increase in the production of both free range and organic poultry meat in many parts of the world. Since 2006, many countries including the European Union (EU), has banned the use of antibiotic growth promoters (AGP's) in the poultry industry, encouraging new explorations of alternatives for AGP's (Grashorn, 2010).

Bennett *et al.* (2011) proposed the use of diatomaceous earth (DE) to reduce parasite load, improve body weight gain, as well as egg production in layer birds. Diatomaceous earth is an inert dust that is formed by milling remaining phytoplankton (diatoms) (Alves *et al.,* 2006).

Diatomaceous earth consisting of less than 7% crystalline silica is generally recognized as a safe food additive (Fields, 2000). Bernard *et al.* (2009) reported an improvement in weight gain of Spanish/Boer crossed female goats, when dosed with a mixture of 1.77 g to 3.54 g DE in 150 ml distilled water for a period of eight days. Furthermore, Adeyemo (2013) also reported DE to have a positive impact on the weight gain of broiler birds. Results from these reports caused speculations regarding the possible usage of DE as an alternative feed additive in place of AGP's for the feed industry. The aim of this study was to evaluate the effect of dietary DE inclusion levels on the productive performance and carcass characteristics of broiler birds.

4.2 Growth parameters

The results of the effect of supplementary diatomaceous earth on the productive performance of the different dietary treatment groups are illustrated in Table 4.1. Values for average daily feed intake (ADFI), average daily weight gain (ADG) and feed conversion ratio (FCR) showed no differences (P >0.05) between the different DE inclusion levels.

Table 4. 1 Effect (mean ± SE) of dietary inclusion levels of diatomaceous earth on the production performances of broilers between D17-42 of age

		DE inclusion level (%)						
Parameters	Age (days)	Control	0.5	1.0	1.5	2.0	*P*	CV (%)
ADFI[1]	17-42	152.13 ± 1.87	153.34 ± 2.71	150.90 ± 1.62	152.33±1.49	152.01 ± 1.46	N.S.	3.04
ADG[2]	17-42	76.45 ± 0.49	76.87 ± 1.66	75.24 ± 0.81	75.66 ± 0.82	73.34 ± 0.56	N.S.	3.13
FCR[3]	17-42	1.99 ± 0.02	2.00 ± 0.01	2.00 ± 0.01	2.01 ± 0.01	2.07 ± 0.02	N.S.	1.80
Liveability (%)	0-42	98.67	99.33	99.33	98.00	100.00	N.S.	1.71
PEF[4]	0-42	287	294	284	285	272	N.S.	3

N.S.: Not significantly different (P>0.05).

[1] Average daily feed intake (g/bird/day).

[2] Average daily gain (g/bird/day).

[3] Feed conversion ratio (g/g).

[4] Performance efficiency factor.

Results from this study indicate that the 0.5% DE treatment resulted in the numerical highest (P >0.05) ADFI (153.34 ± 2.71 g/b/d) values, while the 1.0% DE inclusion resulted in the lowest ADFI (150.90 ± 1.62 g/b/d) during the experimental period (D17-42). Similar findings were recorded by EL-Husseiny *et al.* (2008), which indicted that DE inclusion in poultry diets had no effect (P >0.05) on the feed intake and FCR of the birds. Furthermore, Modirsanei *et al*. (2008) and Adeyemo (2013) observed similar findings that birds supplemented with DE in their diets, showed no significant differences (P >0.05) in their feed intake and FCR.

However, the results from the present study contradict Bennett *et al.* (2011) who observed that free-range layer hens supplemented with DE had a better feed intake than hens under a normal layer diet. However, differences between the present study and Bennett *et al.* (2011) could most probably be ascribed by the differences in the genotype, age of the bird, as well as housing, production system and health status of the birds. Although the ADG did not differ (P >0.05) between the treatments, it is noticeable that the control treatment (76.45 ± 0.49 g/b/d) and the 0.5% DE inclusion (76.87 ± 1.66 g/b/d) had the numerical highest (P >0.05) ADG between D17-42.

The results of the present study are in agreement with Adeyemo (2013) who indicated that dietary supplementary DE did not have any beneficial effect (P >0.05) on the weight gain of broilers. Furthermore, the results were also similar to that of Bernard *et al.* (2009) which showed no difference (P >0.05) in growth parameters of goats supplemented with DE.

DE inclusion levels has no effect (P >0.05) on the FCR of broilers in the present study. However, the numerical lowest FCR (1.99 ± 0.02) was recorded for the control treatment (0% DE inclusion), while the FCR (2.07 ± 0.02) of the 2.0% DE inclusion were the highest (P >0.05). These results partly agree with EL-Husseiny *et al.* (2008) who indicated that supplementing DE in poultry diets resulted in a poor FCR of the birds. Furthermore, Larrison *et al*. (2010) also reported that poultry litter amended with DE had no effect on FCR of birds at 6 weeks of age. Similarly, Kiaei *et al*. (2002) observed that 2% DE inclusion in broiler diets had no effect on both body weight (BW) and FCR of the birds. On the contrary, Adebiyi *et al*. (2009) reported that supplemental dietary DE improved FCR of broilers. Tran *et al*. (2015) also reported that supplementary DE in turkey diets improved their FCR and BW.

There were no significant differences (P >0.05) in the performance efficiency factor (PEF) and liveability (%) among all the five treatment groups. The 2.0% DE inclusion resulted in the numerical highest (P >0.05) liveability (100%), while the control treatment had the numerical lowest (98.67%) liveability. Although not statistically different (P >0.05), the 0.5% DE inclusion had the highest (295) PEF, while that of the 2.0% DE inclusion were the lowest (272). These findings are in agreement with Modirsanei *et al*. (2008) who observed that DE inclusion in poultry diets had no significant effect on the performance efficiency index (PEI) of the birds.

High values for liveability in this study were in contrary proportion with results of ELHusseiny *et al*. (2008) that showed a high mortality rate in chickens supplemented with DE in their diets. Although not statistical significant (P >0.05), the high liveability percentages in DE fed birds might be due to the fact that DE contains silicon dioxide, which is responsible for bone developments and mineralization. It could therefore be suggested that DE supplementation in the birds' diets assisted with the birds' leg bone development.

The results of the study are in disagreement with that of Sun *et al.* (2005) who observed that birds given supplementary natural mineral clay (DE) resulted in higher mortalities and a decreased growth performance. In this study, the lack of any noticeable positive responses from the experimental birds fed the DE may be partially attributed to the fact that DE has no supplemental nutritional role in poultry feed, and it rather acts as a nutrient diluent than a feed additive. Furthermore, the marginal differences observed in certain production parameters, may be due to factors such as adequate nutritional level of the diets, reduced competition for feed and water space amongst birds in relation to a low stocking density. Moreover, there is minimum to no disease challenge in a semi-environmental controlled house.

4.3 Carcass characteristics

The results for live body weight (g), dressing percentage, carcass weight (g), breast, thigh, drumstick as well as wing weight (g), are presented in Table 4.2. As alluded in section 4.2, the dietary inclusion level of DE did not result in any differences (P >0.05) between the experimental treatments. The 0.5% DE inclusion resulted in the numerical highest (P >0.05) mean live weight (2509 g), while birds within the 2.0% DE treatment had the lowest (P >0.05) (2384 g) live weights. The results of this study are in agreement with McLean *et al*. (2005) who observed no significant differences in live body weight between beef cows fed DE and cows in the drench group. Similar findings were observed by Aguilar *et al.* (2009) who reported that oral administration of DE to mice for 21 to 24 consecutive months had no positive effect on their body weights. However, in a second study on sheep McLean *et al*. (2005) reported that ewes supplemented with DE had significantly heavier live body weights than ewes in the drench group. Similarly, Osweiler and Carson (1997) found that lambs receiving DE supplemented feed showed slightly higher weight gain. Furthermore, Bernard *et al*. (2009) also reported an increase in the live weight of parasite infected goats, when treated with DE.

Although not significantly different (P >0.05) it seems that the 0.5% and 1.0% DE inclusion had the numerical highest (72.9%) dressing percentage while that of the control group was marginally lower (72.5%). These results were in agreement with ELHusseiny *et al*. (2008) who reported that DE supplementation in broiler diets had no effect (P >0.05) on body weight gain and dressing percentage. The 0.5% DE inclusion resulted in the numerical highest (P >0.05) carcass weight (1832 g), while the 2.0% DE inclusion had the lowest carcass weight (1733 g).

It was further observed that the 0.5% DE inclusion also resulted in the numerical highest (P >0.05) breast (783 g) and thigh (501 g) weight, while 2.0% DE inclusion scored the lowest on both breast (731 g) and thigh (483 g) weight. Additionally, 0.5% DE inclusion had the numerical highest weights for the drumstick (285 g) and wing (222 g) and the control group with the lowest (P>0.05) drumstick (270 g) and wing (214 g) weights. Although these results were not significantly different from the other treatments, it was invariably anticipated since the 0.5% DE inclusion treatment resulted in a numerically improved (P >0.05) live weight, carcass weight and dressing percentage when compared to the 2.0% DE inclusion.

Table 4.2 Effect (mean ± SE) of diatomaceous earth inclusion level on carcass characteristics of broilers at 42 days of age

	DE inclusion level (%)					
Parameters	Control	0.5	1.0	1.5	2.0	*P*
Live weight (g)	2456.21±54.32	2509 ± 57.12	2399.04 ± 8.87	2428.29 ± 67.23	2384.17 ± 51.38	N.S.
Dressing (%)	72.49 ± 0.48	72.85 ± 0.47	72.85 ± 0.34	72.73 ± 0.28	72.67 ± 0.31	N.S.
Carcass weight (g)	1780.54 ± 40.03	1831.46 ± 42.99	1747.71 ± 36.99	1767.63 ± 51.81	1732.83 ± 38.51	N.S.
Breast (g)	756.75 ± 21.81	783.21 ± 18.88	731.17 ± 15.60	747.38 ± 19.91	730.96 ± 17.28	N.S.
Thigh (g)	492.29 ± 18.14	500.92 ± 13.43	484.75 ± 12.04	485.17 ± 15.96	482.63 ± 11.72	N.S.
Drumstick (g)	267.29 ± 7.13	285.79 ± 8.26	275.58 ± 7.73	278.42 ± 9.03	269.96 ± 6.67	N.S.
Wing (g)	204.67 ± 5.18	222.75 ± 4.83	215.33 ± 5.00	218.75 ± 7.06	213.63 ± 5.45	N.S.

N.S.: not significantly different (P>0.05)

4.4 Internal organ weights

The effect of dietary inclusion level of DE on heart, liver and gizzard weights are presented in Table 4.3. There were no differences (*P* >0.05) observed between any of the treatments means for heart and liver weights. However, the 0.5% DE inclusion had the numerical highest (*P* >0.05) heart weight (10.09 g) while that of the 1.5% DE inclusion was the lowest (9.28 g). Additionally, although not different (*P* >0.05), it is noticeable that the 0.5% DE inclusion had the numerical highest liver weight (47.95 g), while that of the 2.0% DE inclusion was the lowest (42.84 g). These results are similar to that of Denli and Okan (2006) who reported that the addition of DE in broiler diets did not result in an increased liver weight. Modirsanei *et al*. (2008) reported similar findings where DE inclusion had no significant effect on liver weights of broilers. The results of this study are also in partial agreement with that of Karaoglu *et al*. (2004) who reported that supplementary DE in broiler diets had no effect on carcass quality and internal organ weights. However, there were significant differences observed (*P* <0.05) with regard to the gizzard weight amongst the different treatment groups. The 0.5% DE inclusion resulted in the highest (*P* <0.05) gizzard weight (38.93 g), while the gizzard weight of the 1.5% DE inclusion was the lowest (34.18 g). However, it is unknown what could have caused the significant higher gizzard weight in the 0.5% DE inclusion treatment group, and there is no documented literature to support the phenomenon of this research finding.

Table 4.3 Effect (mean ± SE) of dietary inclusion level of DE on organ weight (g) at slaughter (D42).

DE inclusion (%)	Heart (g)	Liver (g)	Gizzard (g)
Control	$9.65^{a} \pm 0.37$	$44.63^{a} \pm 1.24$	$37.22^{ab} \pm 0.94$
0.5	$10.09^{a} \pm 0.44$	$47.95^{a} \pm 1.83$	$38.93^{a} \pm 1.36$
1.0	$9.52^{a} \pm 0.28$	$45.04^{a} \pm 2.06$	$35.79^{ab} \pm 1.01$
1.5	$9.28^{a} \pm 0.36$	$45.33^{a} \pm 1.44$	$34.18^{b} \pm 1.44$
2.0	$9.46^{a} \pm 0.29$	$42.84^{a} \pm 1.36$	$36.25^{ab} \pm 0.85$
P	0.56	0.28	0.05

$^{a,\,b}$ Means with different superscripts in the same column differ significantly (P<0.05).

4.5 Litter moisture content

The results regarding the effect of dietary DE inclusion level on litter moisture content are presented in Table 4.4.

As expected, the dry matter content of the litter decreased (90% to 70%) with an increase in bird age. Dietary DE inclusion had no effect (P >0.05) on the litter moisture between D17- 42 of age. Although, not significantly different (P >0.05), it seems that the control treatment group had the numerical lowest (73.61 g) litter DM when compared to the higher inclusion levels of 1.0%- 2.0%.

The moisture values of this study are in agreement with that of Larrison *et al*. (2010) who reported that DE inclusion to broiler diets did not improve (P >0.05) the DM content of litter. Similarly, Kiaei *et al*. (2015) also suggested that DE supplementation in poultry diets has no beneficial effect on the litter moisture and quality. On the contrary, Tran *et al*. (2015) suggested that supplementary silicon dioxide in turkey diets reduced the litter moisture, pH and decreased the conversion of NH_4^+ to NH_3, thereby reducing the nitrogen losses from the litter and improving litter quality.

Although the research findings for the litter moisture were not significant, 1% DE supplementation in the broiler diet partially decreased litter moisture, suggesting that 1% DE inclusion in poultry diets improves litter moisture and nitrogen retention to a marginal extent.

Table 4.4 Effect (mean ± SE) of dietary DE inclusion levels on the dry matter (DM) content of broiler litter between D17-42 of Age.

		DE inclusion level (%)						
Parameter	Age (day)	Control	0.5	1.0	1.5	2.0	*P*	CV (%)
Dry Matter (%)	17-42	73.61± 1.021	74.89± 0.47	76.40± 1015	76.37± 0.74	76.02± 1.14	N.S	3.20

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CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The results of the present study indicate that the dietary inclusion of diatomaceous earth to a maximum of 1.5% in broiler diets has no detrimental effect on production and carcass characteristics of broilers. However, present results also indicated no beneficial effect of dietary DE inclusion on average daily feed intake (ADFI), feed conversion ratio (FCR), average daily gain (ADG) and performance efficiency factor (PEF).

The lack of significant effects of dietary DE inclusion on most of the parameters, studies might be ascribed to the fact that DE has no supplementary nutritional role in poultry feed and that it rather acts as a nutrient diluent than a feed additive. Additionally, since all the diets used during this study contained both antibiotic growth promoters (AGP's) as well as anti-coccidial drugs, it could be suggested that the standard medication inclusion might have over-shadowed the functionality of the supplemental DE inclusion. Furthermore, dietary inclusion of DE did not improve carcass characteristics and primal meat cuts of broilers. Moreover, the findings of this study also concluded that supplementary DE had no significant effect on internal organ weight. Lastly, the results of this study also suggest that dietary inclusion of DE has no significant effect on the DM-content of litter.

5.2 Recommendations

Although supplementary DE had no beneficial effect on production and carcass characteristics of broilers in the current study, further studies need to be conducted to evaluate the effect DE inclusion on litter quality (litter pH, nitrogen & moisture content), production and carcass characteristics.

Chapter 6

ADDENDUM A

Effect of dietary inclusion levels of diatomaceous earth on production and carcass characteristics of broilers

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Abstract

This study was done to investigate the effect of diatomaceous earth (DE) inclusion levels on the growth performances and carcass quality characteristics of broilers. A total of 750 as-hatched day-old Arbor Acres broiler chicks were randomly allocated to five experimental treatments (n=150 birds/treatment). A standard commercial broiler diet consisting of a three phase feeding regimen (Starter: D0-16, Grower: D17-35 & Finisher: D36-42) was used during the experimental period as the control diet (0% DE inclusion). All the broilers received the control diet for the first 16 days, without any additional DE supplementation. From D17 onwards (25 day period), birds received their respective experimental diets whereby the DE was mixed with the control diet at respectively 0.5%, 1.0%, 1.5% and 2.0% inclusion levels. Feed and water provision was at an *ad libitum* basis throughout the experimental period, whereas a photoperiodic period of 18 hr light and 6 hr darkness (18H:6D) were used. Brooding temperature was gradually decreased from 33 ˚C (D0) to 24 ˚C on D21 of age, while birds were housed on pine wood shavings at a floor density of 11.5 birds/m^2. At D42 of age, 24 birds/treatment (n=12♂ & 12♀/treatment) were fasted overnight before being weighed and slaughtered. Internal organs such as the heart, gizzard and liver weights were recorded after evisceration of the carcasses, while carcasses were cut into eight-piece portions to determine the effect of DE inclusion on carcass characteristics.

Data were statistically analysed (P <0.05) using a fully randomised one-way ANOVA procedure. Treatment 5 (2.0% DE inclusion) resulted in the highest (P <0.05) feed conversion ratio (FCR) (2.07) and the lowest (P <0.05) performance efficiency factor (PEF) (272). No clear trends could be established regarding the DE inclusion level on production performance of birds. In general, it can be concluded that dietary DE inclusion level had no effect (P >0.05) on most of the production and carcass quality traits. The results of the present study suggest that the inclusion of up to 1.5% DE in broiler diets during the growing and finishing phases will not have (P >0.05) a negative effect on broiler production parameters and carcass quality characteristics.

Keywords: Broilers, Diatomaceous earth, production & carcass characteristics.

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Introduction

The poultry industry has in recent years occupied a leading role among agricultural industries within South Africa, with poultry meat and eggs serving as an important source of high quality animal protein (Zarin *et al.,* 2007). The main role of broiler production is to improve the profitability of broiler meat production by minimizing feed and/or input costs. Therefore, success in poultry meat production has been related to the improvement in growth performance and carcass yield, by means of improving breast meat yield and reducing abdominal fat (Zerehdaran *et al*., 2004).

The sub-therapeutic use of antibiotics in poultry feed has become more undesirable due to traces of chemical residues being apparent in meat and meat products, coupled with the increasing development of antibiotic-resistant bacterial population in humans (Adebiyi *et al*., 2009). In recent years, most European Union (EU) countries have banned the use of antibiotics as a growth promoting agent, forcing many feed producers to undergo voluntary withdrawal of these additives, resulting in a steady increase of organically produced eggs and poultry meat (Grashorn, 2010). Graham *et al*. (2007) further suggested that the production costs could be reduced with the exclusion of antibiotics in broiler feed.

However, free range poultry are more prone to parasitic infestations than any other commercially produced poultry (Bennett *et al.,* 2011). Parasitic infestation in a production unit can cause health implications such as impaired weight gains and a decrease in egg production as well as an increased mortality rate. Graham *et al.* (2007) and Bennett *et al*. *(*2011) suggested that there is a need for an effective and safe method for the treatment of parasites to improve organic poultry production.

Herbs, fossil shell flour and spices have received an increasing attention as possible growth promoter additive references (EL Tazi *et al*., 2014). Macy (2000) proposed the addition of diatomaceous earth in the diets to control parasites and subsequently improve certain production factors, such as the average daily gain (ADG) and feed conversion ratio (FCR) of productive chickens.

Diatomaceous earth (DE) is obtained from geological deposits of diatomite, which are fossilized sedimentary layers of microscopic algae called diatoms. DE is made up mainly of silicon oxide (SiO_2) and functions as an insecticide through physical mechanization (Fields *et al.*, 2002).

Dawson (2004), as well as Maurer *et al.* (2009), stated that the use of DE on tree swallows has shown to control ecto-parasite infestation and reduce poultry red mite (*Dermanyssus gallinae*) survivability *in vitro*. Bennett *et al*. (2011) also suggested that feeding supplementary DE to laying hens can improve feed conversion efficiency and egg production. Similar findings were reported by Bernard *et al*. (2009) where he observed an improvement in the weight gain of parasite infested goats treated with DE. The aim of the study was to investigate the effect of dietary inclusion level of DE on the production and carcass characteristics of broilers.

Materials and methods

The study was conducted at the broiler experimental facilities of the University of the Free State (UFS) within a six-week period following the approval by the Animal Ethics Committee of the University of the Free State (Experiment No. 04/2014).

A total of 750 day-old Arbor Acre (as hatched) broilers were obtained from a commercial hatchery close to Bloemfontein and randomly allocated to the five dietary treatments (n=150/treatment). All birds were housed in a semi-environmental controlled environmental building, which was equipped with temperature and photo-periodic regulating equipment. Within the building, 30 floor pens (2.2 m^2/pen) were used for the rearing of each of the replicate groups of the birds (5 treatments x 6 replicates/treatment/25 birds/replica), according to the procedures of Adedeji *et al.* (2014) and Sadeghi *et al.* (2014). All the birds were weighed as a replicate group on arrival (D0) and randomly allocated to the various floor pens, resulting in a population density of 11 birds/m^2 (Mallet *et al.*, 2005).

Pine wood shavings were used as deep litter bedding and each pen was provided with a single tube feeder, "bell-shaped" water-drinker and an infra-red lamp for additional spot heating (Mallet *et al.*, 2005). During the first 7 days of the study, smaller "chick" feeder trays and drinking fonts were used to supply feed and water to the young birds (Zerehdaran *et al.*, 2004). Feed and water provision was on an *ad libitum* basis, throughout the experimental period (Chehraghi *et al.*, 2013). A photoperiod of 23 hr light and 1 hr darkness (23L:1D) was implemented for the first 5 days of the experiment. Thereafter, the schedule was reduced to 18 hr light and 6 hr darkness (18H:6D) for the remaining 37 days of the study period. Brooding temperature was gradually decreased from 33 ˚C (D0) to 24 ˚C at 21 days of age. A standard commercial broiler diet consisting of a three-phase feeding regime (starter, grower, and finisher) was used during the experimental period of 42 days. The feeding regime of the three dietary phases was as follows (McGroven *et al.*, 1999):

1. Starter: Day 0-16
2. Grower: Day 17- 35
3. Finisher: Day 36- 42

During this study, the supplementary dietary inclusion of diatomaceous earth (DE) was implemented only during the grower (D17-35) and finisher (D36-42) phases (Bennett *et al*., 2011). In total, birds were subjected to supplemental dietary DE for a maximum period of 25 days before termination of the study (D42). Dietary inclusion of DE occurred with 0.5% increments as follows:

Treatment 1: control diet (0% DE)

Treatment 2: control diet + 0.5% DE

Treatment 3: control diet + 1.0% DE

Treatment 4: control diet + 1.5% DE

Treatment 5: control diet + 2.0% DE

Body weight and feed intake of each replica group were determined weekly in the following sequence: Day 0, 7, 14, 17, 21, 28, 35 and 42 (Mallet *et al.*, 2005). Weekly mortalities were recorded and expressed as a percentage and considered when calculating mean feed intake and body weight gain of each replicate (Benabdeljelil & Ayachi, 1996). The feed conversion ratio was calculated on a weekly basis for each of the replicate pens and expressed on a gram feed intake/gram body weight gain basis (g/g) (Mallet *et al.*, 2005). Ambient temperature (minimum & maximum) was recorded on a daily basis at 08H00. On completion of the study (D42), 24 birds per treatment (n=12 male & n=12 female) were individually weighed, marked with a leg tag and fasted for 12 hours before slaughtering at a registered small scale poultry abattoir. After slaughtering, individual carcasses were weighted (wet weight) and expressed as a percentage to live weight (Zerehdaran *et al.*, 2004; Laudadio & Tufarelli, 2010). Carcasses were individually cut into eight (8) piece portions (breast, drumstick, thigh and wing X 2) to determine the meat yield of each specific portion. Furthermore, internal organs such as the hearts, livers and gizzards were individually eviscerated and weighed for further calculations using the procedures of Adedeji *et al.* (2014).

At the end of experimental period (D42), the performance efficiency factor (PEF) was calculated, based on the age of the broilers at slaughter (days), the average live weight (kg/bird), liveability (%) and FCR (g/g) of the birds. The advantage of using the PEF is that all factors mentioned above are considered simultaneously and it gives a reasonable idea of the overall efficiency. The PEF was calculated using the following equation (Moneim *et al*., 2014).

$$PEF = \frac{\text{Live weight (kg) x Liveability (\%)}}{\text{Age at depletion x FCR}} \times \frac{100}{1}$$

To determine the effect of the dietary DE inclusion level on the production performance and carcass composition data of individual collection weeks was pooled and analyzed as a mean. All the data were analyzed (P<0.05) using a fully randomized one-way ANOVA procedure of the SAS programme (SAS, 2014). Tukey Kramer's standardized range (HSD) test was used to illustrate differences between treatment means as identified by the analysis of variance procedure (Morrison *et al.,* 2013).

Results and Discussions

The results of the effect of supplementary diatomaceous earth on the productive performance of the different dietary treatment groups are illustrated in Table 1. Values for average daily feed intake (ADFI), average daily weight gain (ADG) and feed conversion ratio (FCR) showed no differences (*P* >0.05) between the different DE inclusion levels.

Table 1 Effect (mean ± SE) of dietary inclusion levels of diatomaceous earth on the production performances of broilers between D17-42 of age.

		DE inclusion level (%)					
Parameters	Age (day)	Control	0.5	1.0	1.5	2.0	*P*
ADFI[1]	17-42	152.13±1.87	153.34±2.71	150.90±1.62	152.33±1.49	152.01±1.46	N.S.
ADG[2]	17-42	76.45±0.49	76.87±1.66	75.24±0.81	75.66±0.82	73.34±056	N.S.
FCR[3]	17-42	1.99±0.02	2.00±0.01	2.00±0.01	2.01±0.01	2.07±0.02	N.S.
Liveability (%)	17-42	98.67	99.33	99.33	98.00	100.00	N.S.
PEF[5]	0-42	287	294	284	285	275	N.S.

N.S. Not significantly different (*P*>0.05).

[1] Average daily feed intake (g/bird/day)

[2] Average daily gain (g/bird/day).

[3] Feed conversion ratio (g/g).

[4] Performance efficiency factor.

Results from this study indicate that the 0.5% DE treatment resulted in the numerical highest (*P* >0.05) ADFI (153.34 ± 2.71 g/b/d) values, while the 1.0% DE inclusion resulted in the lowest ADFI (150.90 ± 1.62 g/b/d) during the experimental period (D17-42). Similar findings were recorded by EL-Husseiny *et al.* (2008), which indicted that DE inclusion in poultry diets had no effect (*P* >0.05) on the feed intake and FCR of the birds. Furthermore, Modirsanei *et al*. (2008) and Adeyemo (2013) observed similar findings that birds supplemented with DE in their diets, showed no significant differences (*P* >0.05) in their feed intake and FCR.

However, the results from the present study contradict Bennett *et al.* (2011) who observed that free-range layer hens supplemented with DE had a better feed intake than hens under a normal layer diet. However, differences between the present study and Bennett *et al.* (2011) could most probably be ascribed by the differences in the genotype, age of the bird, as well as housing, production system and health status of the birds. Although the ADG did not differ (*P* >0.05) between the treatments, it is noticeable that the control treatment (76.45 ± 0.49 g/b/d) and the 0.5% DE inclusion (76.87 ± 1.66 g/b/d) had the numerical highest (*P* >0.05) ADG between D17-42.

The results of the present study are in agreement with Adeyemo (2013) who indicated that dietary supplementary DE did not have any beneficial effect (*P* >0.05) on the weight gain of broilers. Furthermore, the results were also similar to that of Bernard *et al.* (2009) which showed no difference (*P* >0.05) in growth parameters of goats supplemented with DE.

DE inclusion levels has no effect (*P* >0.05) on the FCR of broilers in the present study. However, the numerical lowest FCR (1.99 ± 0.02) was recorded for the control treatment (0% DE inclusion), while the FCR (2.07 ± 0.02) of the 2.0% DE inclusion were the highest (*P* >0.05). These results partly agree with EL-Husseiny *et al.* (2008) who indicated that supplementing DE in poultry diets resulted in a poor FCR of the birds. Furthermore, Larrison *et al*. (2010) also reported that poultry litter amended with DE had no effect on FCR of birds at 6 weeks of age. Similarly, Kiaei *et al*. (2002) observed that 2% DE inclusion in broiler diets had no effect on both body weight (BW) and FCR of the birds. On the contrary, Adebiyi *et al*. (2009) reported that supplemental dietary DE improved FCR of broilers. Tran *et al*. (2015) also reported that supplementary DE in turkey diets improved their FCR and BW.

There were no significant differences (*P* >0.05) in the performance efficiency factor (PEF) and liveability (%) among all the five treatment groups. The 2.0% DE inclusion resulted in the numerical highest (*P* >0.05) liveability (100%), while the control treatment had the numerical lowest (98.67%) liveability. Although not statistically different (*P* >0.05), the 0.5% DE inclusion had the highest (295) PEF, while that of the 2.0% DE inclusion were the lowest (272). These findings are in agreement with Modirsanei *et al*. (2008) who observed that DE inclusion in poultry diets had no significant effect on the performance efficiency index (PEI) of the birds. High values for liveability in this study were in contrary proportion with results of ELHusseiny *et al*. (2008) that showed a high mortality rate in chickens supplemented with DE in their diets.

Table 2 Effect (mean ± SE) of diatomaceous earth inclusion level on carcass characteristics of broilers at 42 days of age

	DE inclusion level (%)				
Parameters	Control	0.5	1.0	1.5	2.0
Live Weight (g)	2456.21±54.32	2509±57.12	2399.04±8.87	2428.29±67.23	2384.17±51.38
Dressing (%)	72.49±0.48	72.85±0.47	72.85±0.34	72.73±0.28	72.67±0.31
Carcass Weight[1]	1780.54±40.03	1831.46±42.99	1747.71±36.99	1767.63±51.81	1732.83±38.51
Breast (g)	756.75±21.81	783.21±18.88	731.17±15.60	747.38±19.91	730.96±17.28
Thigh (g)	492.29±18.14	500.92±13.43	484.75±12.04	485.17±15.96	482.63±11.72
Drumstick (g)	267.29±7.13	285.79±8.26	275.58±7.73	278.42±9.03	269.96±6.67
Wing (g)	204.67±5.18	222.75±4.83	215.33±5.00	218.75±7.06	213.63±5.45

[1] Carcass weight (g).

The results of the study are in disagreement with that of Sun *et al.* (2005) who observed that birds given supplementary natural mineral clay (DE) resulted in higher mortalities and a decreased growth performance. In this study, the lack of any noticeable positive responses from the experimental birds fed the DE may be partially attributed to the fact that DE has no supplemental nutritional role in poultry feed, and it rather acts as a nutrient diluent than a feed additive. Furthermore, the marginal differences observed in certain production parameters, may be due to factors such as adequate nutritional level of the diets, reduced competition for feed and water space amongst birds in relation to a low stocking density. Moreover, there is minimum to no disease challenge in a semi-environmental controlled house.

The results for live body weight (g), dressing percentage, carcass weight (g), breast, thigh, drumstick as well as wing weight (g), are presented in Table 2.
Once again, the dietary inclusion level of DE did not result in any differences (P >0.05) between the five experimental treatments**.** The 0.5% DE inclusion resulted in the numerical highest (P >0.05) mean live weight (2509 g), while birds within the 2.0% DE treatment had the lowest (P >0.05) (2384 g) live weights. The results of this study are in agreement with McLean *et al*. (2005) who observed no significant differences in live body weight between beef cows fed DE and cows in the drench group. Similar findings were observed by Aguilar *et al.* (2009) who reported that oral administration of DE to mice for 21 to 24 consecutive months had no positive effect on their body weights. However, in a second study on sheep McLean *et al*. (2005) reported that ewes supplemented with DE had significantly heavier live body weights than ewes in the drench group. Similarly, Osweiler and Carson (1997) found that lambs receiving DE supplemented feed showed slightly higher weight gain. Furthermore, Bernard *et al*. (2009) also reported an increase in the live weight of parasite infected goats, when treated with DE.

Although not significantly different (P >0.05) it seems that the 0.5% and 1.0% DE inclusion had the numerical highest (72.9%) dressing percentage while that of the control group was marginally lower (72.5%). These results were in agreement with ELHusseiny *et al*. (2008) who reported that DE supplementation in broiler diets had no effect (P >0.05) on body weight gain and dressing percentage. The 0.5% DE inclusion resulted in the numerical highest (P >0.05) carcass weight (1832 g), while the 2.0% DE inclusion had the lowest carcass weight (1733 g).

It was further observed that the 0.5% DE inclusion also resulted in the numerical highest (P >0.05) breast (783 g) and thigh (501 g) weight, while 2.0% DE inclusion scored the lowest on both breast (731 g) and thigh (483 g) weight. Additionally, 0.5% DE inclusion had the numerical highest weights for the drumstick (285 g) and wing (222 g) and the control group with the lowest (P>0.05) drumstick (270 g) and wing (214 g) weights. Although these results were not significantly different from the other treatments, it was invariably anticipated since the 0.5% DE inclusion treatment resulted in a numerically improved (P >0.05) live weight, carcass weight and dressing percentage when compared to the 2.0% DE inclusion.

Conclusions

Results of present study indicated that the dietary inclusion of diatomaceous earth to a maximum of 1.5% in broiler diets has no detrimental effect on broiler performance. Although supplementary DE had no beneficial effect on production performance and carcass characteristics of broilers. Further studies need to be conducted to evaluate DE inclusion on bedding material to improve litter quality (moisture and nitrogen content), productive performance and carcass characteristics.

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