

Effects of *Aloe ferox* in drinking water, on growth performance, blood parameters, meat quality, fatty acid profile and oxidative stability of broiler meat

By

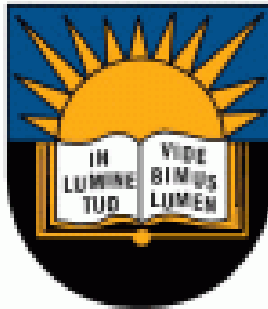
EVELYN TATENDA KAMBA

A Dissertation submitted in fulfillment of the requirements for the degree of

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Department of Livestock and Pasture Science

Faculty of Science and Agriculture



University of Fort Hare
Together in Excellence

Alice Campus, South Africa

Supervisors: Dr. T. T. Nkukwana (Main Supervisor)

Prof. V. Muchenje (Co-supervisor)

Prof. P. J. Masika (Co-supervisor)

November 2014

DECLARATION

I, **Evelyn Tatenda Kamba**, vow that this dissertation has not been submitted to any University and that it is my original work conducted under the supervision of Dr. T. T. Nkukwana, Prof V. Muchenje and Prof. P. J. Masika. All assistance towards the production of this work and all the references contained herein have been duly accredited.

Evelyn Tatenda Kamba

Date

Approved as to style content by:

Dr. T. T. Nkukwana(Main Supervisor)

Prof. V. Muchenje (Co-supervisor)

Prof. P. J. Masika (Co-supervisor)

November 2014

ABSTRACT

The objective of the study was to determine the effects of *Aloe ferox* inclusion in drinking water on growth performance, blood biochemistry, physico-chemical characteristics, fatty acid profile and oxidative stability of broiler meat. The importance of *A. ferox* as a medicinal plant and factors that influence its utilization by communal poultry farmers were also investigated by use of a questionnaire survey. The survey revealed that the majority of respondents (84.6%) faced health challenges in their chickens and many relied (96.2%) on *A. ferox* to treat diseases and control parasites. The study also revealed that the choice of medicine (traditional or conventional) was influenced ($P < 0.05$) by level of education and income. In the second phase of the research, a total of 600 Ross 308 day-old broilers, were randomly put in 6 treatment groups with 4 replicates, each having 25 birds. Fresh aqueous *A. ferox* leaf juice (ALJ) was administered in drinking water at a dosage of 20ml/litre to T₁, T₂ and T₃ from day one to day 35, day one to day 14 and day 15 to day 28, respectively. Birds in T₄ and T₅ (positive controls) were treated with terramycin at the recommended dosage of 14g/litre of drinking water from day one to day 6 and from day 15 to 20, respectively; and birds in T₆ (negative control) received distilled water from day 1 to 35. Feed Intake (FI), average daily gain (ADG) and feed conversion ratio (FCR) were calculated for the 5 week trial. After slaughter, carcass characteristics particularly dressing percentage (DP) and relative organ weight (ROW) were calculated. Serum biochemistry was also determined. For meat quality, pH and color were recorded 45 minutes and 24 hours after slaughter from the breast muscle. Fatty acid profiling and oxidative stability were determined using meat samples from the breast and thigh muscles.

The results for growth performance showed that the birds which were given *A. ferox* for the first two weeks (T₂) consumed significantly ($P > 0.05$) more feed (189.4g) than those in the negative

control (159.6g) at the beginning of the starter phase. Subsequently, their ADG recorded on day 7 (27.1g) and day 14 (43.1g) were significantly ($P<0.05$) higher than the negative control (22.8g and 36.2g, respectively). Significant treatment effects ($P<0.05$) for FCR were reported in the 4th week for the birds that received *A. ferox* throughout (T_1 : 3.5). Carcass characteristics were not significantly ($P>0.05$) affected by *A. ferox* inclusion in drinking water. The highest high density lipoprotein (HDL) values (2.78 mmol/L) were yielded in T_2 and T_3 had the lowest values (0.61mmol/L) for low density lipoprotein (LDL). For physico-chemical properties, no significant effects ($P>0.05$) of treatment on pH, colour, cooking loss and tenderness were observed. However, the group treated with *A.ferox* throughout the production cycle, had the highest pH (6.2), lowest lightness (38.5), highest redness (4.1), highest tenderness (13.86N) and the lowest cooking loss (12.6%). Significant treatment effects ($P<0.05$) were observed on the composition of the PUFA eicosatrienoic acid (C20:3c8, 11, 14(n-6)) of the breast muscle which was significantly lower in the *A. ferox* treatment groups than the positive controls. For the thigh muscle, there were significant ($P<0.05$) treatment effects on composition of palmitoleic acid (C16:1c9) and g-linolenic acid (C18:3c6, 9, 12 (n-3)). No significant ($P>0.05$) effects were found on oxidative stability of both thigh and breast muscles. In conclusion, the wide use of *A. ferox* by communal chicken farmers showed its importance as a medicinal plant. Apart from it being an effective medicinal plant, *A. ferox* inclusion in drinking water results in improved FI, ADG, reduced in LDLC and better g-linolenic and palmitoleic acid composition in the meat.

Keywords: *Aloe ferox*, feed intake, average daily gain, feed conversion ratio, blood biochemistry, fatty acid composition.

DEDICATION

I dedicate this work to my loving mother, Mrs E. Kamba and my children Tadiwa Claire and Munyaradzi Tino.

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LIST OF ABBREVIATIONS

a* - Redness

ADG- Average Daily Gain

ALJ- *Aloe ferox* whole Leaf Juice

b* - Yellowness

BWG- Body weight gain

CL- Cooking loss

DP- Dressing percentage

FCR- Feed Conversion Ratio

FI- Feed Intake

HDL- High Density Lipoprotein

L* - Lightness

LDL- Low Density Lipoprotein

MUFA- Mono unsaturated fatty acid

PUFA- Poly unsaturated fatty acid

ROW- Relative organ weight

SFA- Saturated fatty acid

TBARS- Thiobarbituric acid-reacting substances

WBSF- Warner Bratzler Shear Force

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CHAPTER 1: General Introduction

1.1 Background of the study

Chickens play a significant role to both resource limited communities and commercial farmers. In South Africa, chicken meat production increased by 19 093 tonnes in the 2011/2012 period, (Directorate Agricultural Statistics, 2012). Globally, chicken meat consumption has been rising steadily over the years, as a result; production has increased dramatically in the last 10 years by 20-30% (Alabi *et al.*, 2012). The reason for the rise can be attributed to chicken being affordable and a good source of protein, thus resulting in the growing demand of chicken meat. Another reason is that chicken is not considered a taboo in most religions and cultures hence more people consume it without any religious and/or cultural restrictions (Prabakarahh, 2003). Chicken production can also be done by women and children; hence production spans across wider and diverse groups (Mwale and Masika, 2009). As documented by the Directorate Agricultural Statistics (2012), chicken production has contributed significantly to the gross domestic product (GDP) of South Africa with the chicken industry contributing R29 598 000 in 2010.

Currently, resource-limited farmers are mostly involved in the rearing of indigenous breeds, solely because they require low capital input as compared to exotic breeds (Safalaoh and Sankhulani, 2004). The main system of production they practice is free ranging which in itself poses challenges around disease and parasitic infestations due to lack of sufficient biosecurity measures. According to Mwale and Masika (2009), 86% of the households in Centane district, Eastern Cape reported problems with gastro-intestinal parasites in their chickens. Therefore, in a bid to keep the capital input low, the farmers have adopted the use of ethnoveterinary medicines, which are locally accessible and cheap. Previous studies have proven the effectiveness of some

medicinal plants against diseases and parasites, although the efficacy was dependent on concentration of the active compounds (Tipakorn, 2002; Maphosa *et al.*, 2010).

Aloe ferox, is also one of the plants that has found recognition for nutritional, botanical and veterinary uses. It is also popular in the commercial circles where different products have been developed due to properties, which include antimicrobial and laxative properties (Chen *et al.*, 2012). In this light, *A. ferox* added in drinking water can be used for collectively improving intestinal health and growth performance in chickens (De Beer and van Wyk, 2011). On the other hand, serum biochemical profiles as influenced by *A. ferox* can be used to assess the safety of plant extracts on animal health (Park *et al.*, 2014).

Furthermore, meat consumers are increasingly concerned about the quality of meat they ingest (Andersen *et al.*, 2005). Considering the fact that, chickens are an inexpensive source of protein across all social ranks (FAO, 2010), it is necessary to know how medicinal plants affect meat quality. Meat quality attributes like tenderness, juiciness, marbling, color and flavor are of paramount importance. Muchenje *et al.* (2008) and Simela (2005) reported that pH has an effect on meat tenderness, color, juiciness and flavor. The pH of the breast meat measured 15 minutes (pH₁₅) post *mortem*, will give an indication of pale, soft and exudative (PSE) meat. Generally, postmortem pH of the meat is influenced by the biochemical compounds that are included in the diet of chicken (Sanudo *et al.*, 2004).

1.2 Problem Statement and Justification of the study

Aloe species are one of the mostly used native Southern African plants in chicken production particularly by communal farmers who are the custodians of indigenous knowledge (van Wyk, 2011). *Aloe ferox* has been reported to treat and control chicken diseases and parasites, in most

instances, the time period of use is not specified (Mwale *et al.*, 2005; Muchadeyi *et al.*, 2007). As such, the gathering of current information on the extent of use of *A. ferox* and how such use influences the livelihoods of communal farmers is necessitated.

Furthermore, claims by chicken farmers and consumers that *A. ferox* enhances meat quality have been reported (Mwale and Masika, 2009; Chulayo *et al.* 2011). It is also reported that farmers administer *A. ferox* to their chickens until signs of disease disappear regardless of the stage of production of the birds (Mwale and Masika, 2009). Researchers have also reported the digestion-stimulating properties of *A. ferox* among others (Hernandez *et al.*, 2004). In addition, some scholars have established efficacy of *A. ferox* as an antimicrobial plant (Mbanga *et al.*, 2010) and against helminths (Maphosa *et al.*, 2010). However, its effects on growth performance and meat quality of chickens have not been established. Therefore, this research seeks to determine the effect of *A. ferox* inclusion in drinking water at different stages of production.

1.3 Objectives

Main objective

- To determine the extent of use of *Aloe ferox* as a medicinal plant in chicken production together with its effect on growth performance and physico-chemical characteristics of broiler meat.

Specific objectives

- To determine whether socio-economic determinants affect the use of *Aloe ferox* in the management of poultry health by communal chicken farmers.

- To determine the effect of *Aloe ferox* on growth performance, carcass characteristics and blood biochemistry of broilers.
- To determine the effect of *Aloe ferox* on physico-chemical characteristics, fatty acid profile and oxidative stability of broiler meat.

1.4 Hypotheses

The null hypotheses to be tested are:

- Socio-economic determinants do not affect the use of *Aloe ferox* by communal farmers in the management of poultry health;
- *Aloe ferox* has no effect on growth performance, carcass characteristics and blood biochemistry of broilers;
- *Aloe ferox* has no effect on physico-chemical characteristics, fatty acid profile and oxidative stability of broiler meat.

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CHAPTER 2: Literature review

2.1 Introduction

The demand for white meat has been rising steadily over the years due to the improvement in nutritional needs of humans resulting from an increase in the world population (Kyriazakis and Whittemore, 2006). However, chicken production is also important in supporting livelihoods of rural communities in developing countries (FAO, 2002). They are kept as a cheap source of proteins through their meat and eggs. They are also reared for cultural purposes and even as a form of payment during barter exchange. Chicken production is generally done by everyone in the social hierarchy including women and children (Maphosa *et al.*, 2004; Muchadeyi *et al.*, 2004). However, as important as chicken production is to rural communities, their contribution to food security has a lot to be desired.

Due to low capital, no or limited access to veterinary support services and limited information concerning control and treatment of diseases, resource limited farmers have opted to rear indigenous chickens (*Gullus gallus domesticus*) as opposed to exotic breeds particularly broilers (Gueyé, 1999; Dold and Cock, 2001). Indigenous breeds are chosen over broilers because they are hardy and are well adapted to harsh environments (Faranisi, 1995). They are kept under free range production system where they scavenge for food and hence, this makes the capital requirements for indigenous chickens low.

Phytotherapy is defined as the use of herbal medicines consisting of complex mixtures of one or more plants which are used for the management of various diseases (Calixto, 2000). Medicinal plants have been used for centuries for the treatment and control of chicken diseases and parasites (Hoareau and DaSilva, 1999). The use of medicinal plants can be traced back to the era when domestication of livestock began. Phytotherapeutic methods have undergone years of trials that they are generally accepted in rural communities and it is reported that at least 80% of people in developing countries depend largely on indigenous practices for the control and treatment of various diseases affecting both human beings and their animals (WHO, 1999). Nevertheless, little has been documented on the plants used in South Africa and their effect on meat quality. This threatens the loss or dilution of indigenous knowledge as it is passed on from generation to generation orally (Mwale *et al.*, 2005).

2.2 Advantages of phytotherapy

Some reports have indicated that use of medicinal plants is accepted in resource limited farming systems as opposed to conventional medicines (Moreki, 2013). Because of the high costs of conventional drugs, smallholder and/or rural farmers have resorted to the use traditional plant based medicines (Satrija *et al.*, 2001). This can be attributed to the ease of preparation of the herbal medicines, the effectiveness of the medicines against chicken ailments (Moreki, 2010), the medicines presenting no adverse side effects and the biodegradable nature of the plant based medicine (Guèye, 1999). In addition, medicinal plants are collected locally at no cost (Gueye', 1997). Hence, phytotherapy is a financially sound and environmentally friendly concept (Gueye', 2002). Furthermore, traditional practices are the basis of drug development and likewise phytotherapy empowers the rural communities by enhancement of indigenous knowledge systems (Iqbal *et al.*, 2005; Kolawole *et al.*, 2007).

2.3 Economic losses due to chicken diseases and parasites

The prevalence of diseases and parasites is a major constraint to communal farmers and this limits the numbers of chickens being kept at the moment (Guéye, 1997). The high incidence of diseases and parasites can be attributed to poor bio-security measures in rural households (Mungube *et al.*, 2006). Village chickens rely on scavenging for earthworms, insects and scraps from household waste. They travel long distances in search of food and in the process they are in permanent contact with wild birds, contaminated soil and other intermediate hosts (Permin and Hansen, 1998). Hence, lack of adequate infrastructure is a problem in resource limited households. Another reason why diseases and parasites are prominent in village chickens is that there is interaction of different flocks at any given time. The communities rely on a small number of cocks for breeding and this encourages spread of diseases from one flock to another (Permin and Pedersen, 2002). The spread of parasites and diseases is also encouraged by the climatic conditions especially in the tropics and sub-tropical regions where the weather is conducive for reproduction of parasites.

Diseases and parasites result in losses through mortality and also by reducing productivity i.e. reducing the number and quality of eggs and meat. This has adverse implications on food security and on generation of income in rural communities.

Diseases of economic importance that affect chickens in rural communities include Newcastle disease, an infectious disease that is caused by the avian paramyxovirus type 1 (PMV-1) (Njagi *et al.*, 2010). In a survey conducted in the North Eastern Free State province, South Africa, farmers reported 80% mortality of chickens showing signs of Newcastle (Thekiso *et al.*, 2003). Coccidiosis is another disease which causes great economic losses in rural communities and Kinung'hi *et al.* (2004) reported that it causes 11.85% economic loss in smallholder farms.

Mwale and Masika (2009) reported the prevalence of coccidiosis to be 34% in Eastern Cape and that of gastro-intestinal parasites to be 99%. Respiratory distress is also a common occurrence in chicken production.

2.4 Some medicinal plants used in chicken production

Medicinal plants used in chicken production differ from place to place depending on the availability of the plant in the area. For example, *Combretaceae sp.* are used in the treatment of coccidiosis (Naidoo *et al.*, 2008) and is also a rich source of antioxidants. One other plant used in chicken production is *Gunnera sp.* which are used in treating helminthosis. Other plants are used as laxatives and these are mostly used to treat gall sickness. Such plants have the anthrone C-glucoside aloin or barbaloin (van Wyk *et al.*, 1997). *Andrographis paniculata* contains deoxyandrographolide, andrographolide and neoandrographolide which are anti-inflammatory compounds that are responsible for treatment of helminthosis in chickens (Dutta and Sukul, 1982). *Moringa oleifera* leaves are used as anthelmintics (Wassawa and Olila, 2006) and also as a feed supplement (Moyo, 2011).

One of the most prevalent medicinal plants are of the *Aloe sp.* and are found abundantly in sub-Saharan Africa. These plants include *Aloe barbadensis*, *Aloe arborescens*, *Aloe marlotii* and *Aloe ferox* and are used as multi-purpose medicines with anthelmintic, antimicrobial, anti-inflammatory and anti-oxidative properties. They also contain carotenoids, vitamins, terpenoids and phenols among other compounds (O'Brien *et al.*, 2011). They are used to treat Newcastle disease, internal parasites, fowl typhoid, coccidiosis, gall sickness and inflammation (Dold and Cocks, 2001).

2.5 Phytotherapy research in chicken production

Although communal farmers mostly rear indigenous chickens, broiler chickens are also kept in rural communities as a source of income (Kusina *et al.*, 2000). However, because of low capital inputs, communal farmers medicate both indigenous and broiler chickens with medicinal plants. In addition, communal farmers claim that medicinal plants are effective although the efficacy of some plants are yet to be ascertained scientifically. The doses of medicinal plants used in phytotherapy in resource limited farmers cannot be established and this poses risks of toxicity if high doses are used and ineffectiveness and resistance, if lower doses are used. Plants that have been scientifically tested for efficacy like *Moringa olifera* and *Andrographis paniculata* can be introduced in feeds to reduce adverse effects of antibiotics in chicken production (Tipakorn, 2009; Rockwood *et al.*, 2013). Other than evaluating the plants for efficacy only, research can also be done to test toxicity, shelf life, mode of action and also active ingredients of medicinal plants. This can open doors to commercialisation of the plants for the urban smallholder chicken producers market that have no access to the medicinal plants. Further research can also be done to determine the effect of these medicinal plants on growth performance and meat quality.

2.6 Use of *Aloe ferox* in chicken production

Aloe ferox known as bitter aloe is a spiny-edged succulent plant that is mostly found in the sub-saharan Africa and particularly the Cape coastal regions to the southern KwaZulu-Natal (O'Brien *et al.*, 2011; van Wyk, 2013). Human interaction with *A. ferox* in South Africa can be dated back to 200 years ago as evidenced by some San rock paintings (Reynold, 1950; Paterson-Jones *et al.*, 2007; van Wyk, 2011). *Aloe ferox* is mostly known for its medicinal properties which include antihelmintic, anti-viral, anti-fungal and anti-bacterial properties (Park and Lee, 2006; Boudreau

and Beland, 2006). It also has cosmetic benefits to humans (van Wyk, 2013). The efficacy of *A. ferox* as a medicinal plant in chicken production has been proven although the efficacy is highly dependent on the concentration of active compounds (Maphosa and Masika, 2012). *Aloe ferox* is widely used by resource limited farmers to treat and control chicken diseases and parasites (Mwale and Masika, 2009).

2.6.1 Pharmacological properties of *Aloe ferox*

Aloe ferox leaf gel contains volatile polysaccharides particularly β -(1, 4) - linked, poly-dispersed highly acetylated mannans and can be affected by heat, acidity and enzymes (Steenkamp and Stewart, 2007). It also contains 15-40% anthra-quinones including aloin and hydroxyaloines. The aloin is responsible for the *A. ferox* being a laxative and an antibacterial medicinal plant. *A. ferox* also contains Aloe-emodin and chrysophanol which have antibacterial properties. It also contains carboxypeptidase and bradykinase which are enzymes that are involved in anti-inflammation and also for the relief of pain (Duke, 1997). Studies show that 70-97% of *A. ferox* dry weight contains aloeresin A, aloesin, and aloin (both epimers A and B) in a ratio of 4:3:2, respectively (van Wyk *et al.*, 1997). Dihydrocoumarins are also found in the leaf gel and this is responsible for its antioxidative properties (Zhang *et al.*, 2006).

2.6.2 Preparation of *Aloe ferox* for use as a medicinal plant

Communal farmers who are the custodians of ethno-veterinary medicines and practices use *A. ferox* for treatment and control of diseases and parasites in livestock production (Mwale and Masika, 2009). Leaves are generally used and these are prepared by crushing a leaf and mixing it with a litre of water (Masimba *et al.*, 2011). The solution is then given to the chickens until signs of disease have disappeared (Mwale *et al.*, 2005).

2.6.3 Uses of Aloe ferox in broiler production

Growth performance is a central attribute in broiler production hence, over the years broiler breeders have focused on broiler meat production traits with selection mostly focused on feed conversion efficiency and growth rate (Schmidt *et.al*, 2009). It is reported that in the 1940s it took 40 days for broilers to reach a weight of 1.8kg and currently, they reach a market weight of 2.5kg in 40days (Konarzewski *et al.*, 2000). Although a significant change has been noted, broiler production still faces a challenge of reducing the production costs but at the same time ensuring optimum growth performance. Plants of the *Aloe spp.* have been found to contain antioxidants, appetite stimulating and anti-microbial properties which affect growth performance in broilers (Davis *et al.*, 1994; Hernandez *et al.*, 2004). Darabighane *et al.* (2011) reported an increase in feed intake and subsequent Average Daily Gain (ADG) of broilers which were administered with *A. vera*. This can be attributed to an increase in the health status of bird due to phytochemical compounds in *Aloe* which include phenolic acids/polyphenols, sterols, fatty acids, and indoles and due to the above mentioned phytochemical compounds in *A. ferox*, alleviation of cardiovascular symptoms is ensured (Loot *et al.*, 2007). Acemannan in *A. ferox* also increases health status through induction of immune modulation by stimulating microphage production (Zhang, 2006). In addition, *A. ferox* increases the nutritional value of the diet fed to the birds due to the presence of polysaccharides, fatty acids and various proteins.

Aloe ferox is known to work as a laxative and this improve intestinal health and also reduces parasitic load in the gastro-intestinal tract. The presence of aloin as a phytochemical compound of Aloe is responsible for its laxative effect (Akao *et al.*, 1996). Hence, administering Aloe to broilers will reduce constipation and discomfort and will increase growth performance.

Researchers have reported the efficacy of *Aloe ferox* in curbing gastro-intestinal parasites and its efficacy was reported to be at a dose of 500mg/kg (Maphosa and Masika, 2012). Gastro-intestinal parasites reduce the amount of nutrients available for absorption by the host and this reduces average daily gain (ADG) and growth performance in general. Helminths also cause damage in the gastro-intestinal tract and administering *A. ferox* reduces pain and inflammation hence reduces stress and discomfort that can come with lesions in the gut. This can be attributed to the presence of the enzymes carboxypeptidase and bradykinase which work for anti-inflammatory purposes (Duke, 1997). Stress and pain reduces ADG together with feed and water intake and this ultimately reduces the growth performance of chickens.

Aloe ferox has been reported to have anti-microbial properties. It is effective as an anti-bacterial agent against *Streptococcus* bacteria, *Staphylococcus aureus*, *E. coli*, *Mycobacterium tuberculosis* and *Pseudomonas auruginosa* (Reynolds and Dweck, 1999). Aloe-emodin inhibits the activity and growth of *Helicobacter pylori* which cause lesions on the intestinal wall (Wang, 1998). By reducing the bacterial population in the gut, feed conversion efficiency is encouraged since the surface area for absorption of nutrients is increased. Gut microflora also increases the nutrient requirements of the host by competing for nutrients. Aloe is effective as a coccidiostat and this increases the health status of the animal and hence the growth performance (Yim *et al.*, 2011).

The benefit of *A. ferox* in reducing FCR in broilers will also have an impact on the lethargy of the birds. Birds with low FCRs are less fearful and lethargic as compared to birds with high FCRs (Skinner-Noble *et al.*, 2003). This interprets to broilers with high FCRs are prone to high stress levels and this can consequently result in the broilers reducing their feed intake and reduces the growth performance. Hence, it is necessary to ensure that feed conversion efficiencies are kept at their optimum.

As much as *A. ferox* has positive effect on growth performance, adverse effects on the broilers, if any, should be noted. Research shows that *A. ferox* is non-toxic at 5g/kg (Calestino *et al.*, 2013). However, Maphosa and Masika (2012) reported 75% mortality at a dose of 800mg/kg and 100% mortality at a dose of 1600mg/kg. Potential toxicity of the plant was reported after use for more than 14 days continuously (Mwale and Masika, 2009; Maphosa and Masika, 2012). Hence it is necessary to use the plant within the recommended range to ensure optimum growth performance and reduction in mortality due to toxicity.

2.7 Meat quality of broilers

Meat quality encompasses characteristics that include physical, chemical, morphological, biochemical, microbial, sensory, technological, nutritional and culinary properties (Javan *et al.*, 2013; Tougan *et al.*, 2013). Physico-chemical characteristics of meat influence consumer acceptability and nutritional factors with health implications on the consumer (Muchenje *et al.*, 2009). The importance of quality of broiler meat cannot be underestimated as consumers are becoming more concerned and informed about the food they consume. The recent development of organic animal production and consumer requests for food safety and environmentally friendly products may encourage production of quality broilers. The organic market has strong growth, at about 28% annual growth, with the organic meat, fish, and poultry category showing the highest growth, at 55% (Heller, 2006).

The prevailing incidences of contamination of meat by Antibiotic Growth Promoters (AGPs) which reduces the export of South African broiler meat especially to European countries is one of the major constraints affecting poultry production in South Africa (Bunyaphatsara, 2000).

Hence it is necessary to find alternatives of antibiotics so as to ensure trade with other countries in this respect.

The treatment of diseases and parasites is positively correlated to good meat quality and high consumer acceptance. This is because diseases and parasites reduce body condition (Mwale and Masika, 2009) and this in turn will reduce the meat quality of chickens. The effect of *A. ferox* is expected to increase condition of the chicken which increases the meat quality and consumer acceptability (Chulayo *et al.*, 2011). This may be because phytogetic products contain hypocholesterolemic effects and antioxidants which influences the oxidative stability of chicken (Parvar *et al.*, 2013). Furthermore, communal poultry farmers claim that phytotherapy is effective in ensuring good meat quality (Kyarisiima *et al.*, 2011). However, there is need for applied research to substantiate their assertions.

2.7.1 Post mortem pH changes

Post mortem pH decline is important in that it has an impact on meat texture, color and water holding capacity (Aberle *et al.*, 2001). The rate of pH drop and the ultimate level (pH_u) is affected by a variety of factors including nutrition, body condition of an animal, age of animal, aging of the meat and type of the muscle (Sanudo *et al.*, 2004). The rate at which the pH drops may result in Pale, Soft Exudative (PSE) in pork, beef and poultry (Hambrecht *et al.*, 2004). Development of low pH in the muscle causes denaturisation of muscle proteins which in turn causes loss of protein solubility, loss of water- and protein-binding capacity and loss in intensity of muscle pigment coloration (Strydom *et al.*, 2000).

Calkins and Hodgen (2007) reported relationships between pH and sensory characteristics. Fresh meat has a pH of 5.5-6.0 and also has a good buffering ability. Many components that contribute to meat flavor are water soluble hence an increase in pH increases the binding of water soluble

proteins resulting in low cooking loss and high juiciness of meat. Furthermore, broilers that are selected for high breast yield have a low rate of pH decline as compared to slow growing breeds (Berri, 2000).

2.7.2 Meat tenderness

Tenderness is the hardness or softness of meat at chewing or cutting. It is one of the components of palatability. Strydom *et al.* (2000) states that tenderness is the most important factor influencing meat quality. Texture or tenderness is a multi-dimensional attribute and is described in several stages namely partial compression, first bite, chew-down, and residual. Meat tenderness can be affected by pre-slaughter stress, aging of meat, age of the animal. Aging of meat is the time taken between slaughtering and chilling. Shortly after slaughtering, rigor mortis kicks in. Rigor mortis is the phenomenon whereby the skeletal muscles contract causing stiffness of joints. During rigor mortis, tenderness decreases due to contraction of muscles and after rigor mortis tenderness increases due to the muscles loosening up because of proteases. Chulayo *et al.* (2011) recorded that consumers preferred meat from chickens that were treated with *A. ferox*, *Gunerra perpensa* and *Agave sisalana* and perceived it to be more tender than one that was not treated with medicinal plants.

2.7.3 Oxidative stability

The oxidative stability of meat determines the shelf life of the meat. Improving antioxidant capacity of meat enhances acceptability of meat and can be achieved by adding natural antioxidants. Hence, studies have shown that the addition of phytogetic compounds either in drinking water or feed of broilers increases the oxidative potential (Windisch *et al.*, 2008). Aloe contains polyphenols, flavonoids and phytosterols which have antioxidant capacities (Botes *et al.*, 2008). Antioxidants are compounds that prevent and/or delay or retard meat autoxidation

(Shahidi and Wanasundara, 1992; Windisch *et al.*, 2008). Polyphenols in Aloe not only act as an antioxidant but also add nutritional value to the meat. A study by Javan *et al.* (2013) reported that *A. vera* delayed spoilage of chicken breast fillets. Furthermore, the amount of nutritional antioxidants is one of the factors affecting lipid oxidation which results in meat deterioration (Brenes *et al.*, 2008). Phenolic compounds and flavonoids reduce lipid oxidation by attaching to biological polymers and free radicals so that they become stabilized (Milos *et al.*, 2000).

2.7.4 Fatty acid profiling

One of the factors influencing the nutritional value of broiler meat is the fat content of the meat as it has implications on the health of the consumer. Of particular importance is the quantity and quality of fat (Williams, 2000). The recommended daily fat intake is less than 30% of the total energy intake (WHO, 1999). Moreover, focus has been put on reducing the intake of saturated fatty acids (SFAs) and promotion of polyunsaturated fatty acids (PUFAs) (Botsoglou *et al.*, 2012). The ratio of polyunsaturated fatty acids to saturated fatty acids is of significance and desired ratio in chicken meat is 0.1 (Wood *et al.*, 2003). Another ratio of importance is the omega-6 to omega-3 (n-6/n-3) which is an indicator of the risk factor of cardio-vascular disease and is recommended to be less than 4 (Wood *et al.*, 2003). Other than contributing to the nutritional value of the meat, fatty acid content in broiler meat also determines the marbling of the meat (Wood *et al.*, 2003).

Aloe ferox in particular, contains campesterol, and B-sitosterol which are responsible for reduction in blood cholesterol levels. Other fatty acids found in *Aloe spp.* include linoleic, linolenic, myristic, caprylic, oleic, palmitic, and stearic acids (Loot *et al.*, 2007).

Meat quality will determine the consumer acceptability and hence is directly proportional to the demand. Consumers are now more concerned about health issues surrounding the meat they

consume and hence animal producers are finding ways to produce healthier meat and at a low cost of production. Hence, phytogetic compounds can be a replacement for more expensive synthetic compounds.

2.8 Summary of literature review

Phytotherapy is an important aspect in chicken production and is gaining popularity due to the easy availability and accessibility of the plants and also because plant compounds are biodegradable. However, valuable phytotherapeutic knowledge is suffering potential loss or dilution due to lack of documented sources since the knowledge is traditionally passed on from generation to generation orally. *Aloe ferox* is one of the plants of focus and is reported to contain anti-microbial, antihelminthic, anti-carcinogenic and anti-oxidant compounds. Its wide use in communal areas has been reported. Resource limited farmers use it to treat virtually every disease and parasitic conditions that is presented in their chickens but however, the effect of *A. ferox* on growth performance and meat quality is not known. This project will determine the effect of medicinal plants on growth performance, serum biochemistry of broilers together with meat quality, fatty acid composition and oxidative stability of broiler meat.

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CHAPTER 3: Socio-economic determinants in the utilization of *Aloe ferox* to treat chicken ailments in rural communities of Eastern Cape, South Africa

Abstract

The study was conducted to determine the socio-economic determinants and extent of use of *Aloe ferox* rural communities in the management of poultry health. With the use of questionnaires, data were collected from 53 respondents who kept chickens in the Alfred Nzo Municipality, Eastern Cape. Snowball technique was used to target information-rich informants who provided insight on the nature of problems faced in chicken production. About 86.6% of the respondents were female and 34.7% were between 56-70 years; and most (88.7%) relied on social grants. The majority of the respondents had flock sizes ranging from 4-7 birds and only 8% had flock sizes greater than 24 birds. All the respondents reared indigenous chickens and among these only 15.1% kept broilers as well. Most of the respondents (96.2%) ranked the rearing of chickens for both meat and eggs to be of high priority. Amongst these, 84.6% reported having problems with chicken diseases and parasites. According to the signs described by the respondents, the diseases and conditions were Newcastle disease, anaemia due to parasites, respiratory distress, external parasites and worm infestation. Traditional remedies were mostly used to address health issues in the chickens by 53.9% of the respondents, of which 96.2% used *Aloe ferox* prepared by crushing a leaf and mixing it with water and is then administered to the chickens until signs of the disease disappear. Most respondents considered *A. ferox* not to have side effects on chickens and with no residual effects on the meat. The choice of medicine (traditional or conventional) was influenced ($P < 0.05$) by level of education and income. There was no association ($P > 0.05$) between the use of *A. ferox* and the occurrence of diseases and parasites. In conclusion, chickens played important socio-economic roles by contributing to gender equity and food security as they are mainly kept by women for the provision of meat and eggs. Vast health challenges were reported as perceived by the farmers. As such, the farmers in rural areas widely use *A. ferox* to treat and control poultry ailments and they were motivated by their level of education and income. The wide use of *A. ferox* by chicken farmers in the villages studied showed its importance as an alternative to conventional medicines.

Keywords: *Aloe ferox*, medicinal plant, indigenous chickens

3.1 Introduction

Chicken production is a significant part of livestock production in rural communities and plays a role of poverty alleviation by contributing towards food security and income generation. It plays a part in social roles like promotion of gender equality since chickens can be reared by both men and women (Sonaiya, 2007). Culturally, chickens are slaughtered to appease ancestors. Mapiye *et al.* (2008) reported that one of the contributions of chickens to rural farmers is insurance in case of emergency. Gueye' (2002) reported that 80% of the African continent poultry flock is found in the rural areas and 43% of South African population are residents of rural areas (Swatson *et al.*, 2001) and hence the contribution of chickens to rural communities cannot be underestimated.

The production system that is prevalent in rural areas is the free-range system. In resource poor communities, availability of proper infrastructure limits the practicing of intensive chicken production. The high costs of feed, encourages free range system and the rearing of indigenous breeds which are more hardy and resilient. However, because of poor bio-security measures, poultry in rural communities are vulnerable to diseases and parasites as they are in constant contact with other flocks and vectors. Chicken diseases and parasites result in reduced performance and/or mortality of the birds.

The number of birds that are kept in resource limited communal areas is significantly low and this can be attributed to inaccessibility of veterinary support systems, agricultural extension services and commercial drugs (Guèye, 2002). Commercial drugs are unaffordable to a greater portion of rural folks and sometimes they have to travel long distances to access the drugs

(Mwale and Masika, 2009). Hence, communal farmers have resorted to the use of phytotherapy for the treatment of chicken diseases and parasites (Anthony *et al.*, 2005).

Phytotherapy can be defined as the use of concoctions of one or more plants and/or plant-based products for medicinal purposes (Calixto, 2000). Medicinal plants have been used traditionally in rural areas where they are available abundantly and freely. These herbal concoctions have undergone years of trial and error such that many rural folks claim that medicinal plants are effective (Guèye, 1997; Moreki, 2013). Apart from the latter claim, medicinal plants are used because of lack of knowledge in the use of commercial drugs due to illiteracy (Moreki, 2010). In Centane, Eastern Cape, Mwale and Masika (2009) reported that 83.3% of interviewed respondents used medicinal plants to control external and internal parasites. In a study done in Botswana, Moreki (2010) reported that 16% of rural farmers use commercial drugs in combination with herbal concoctions. The above findings indicate that phytotherapy is a significant part of chicken production in communal areas.

Among the plants that are predominantly used in chicken production for disease and parasitic control is *Aloe ferox* commonly known as bitter aloe or red aloe (English) and Ikhala (Xhosa) (Dold and Cocks, 2001). *Aloe ferox* is a perennial, succulent plant which is spiky and grows tall, up to a metre, as a caulescent (single stemmed) plant (Reynolds, 1982). It propagates easily; reaching flowering stage in 4-6 years, depending on the environmental conditions of its habitat (Newton and Vaughan, 1996). The geographical distribution of *A. ferox* in South Africa shows that 45% of the Aloe in South Africa is found in the Cape Province which is divided into Eastern Cape, Northern Cape, Western Cape and part of the North West Province (Newton and Vaughan, 1996). Hence *A. ferox* has adopted the name 'Cape Aloe'.

Aloe ferox has remarkable cosmetic, nutritional and medicinal properties. The ethno botanical uses of *A. ferox* in chicken production, as reported by van Wyk (2013), include ensuring good general health, treatment of lice, reduction of helminthic load and anti-inflammatory purposes. The plant has 3 parts that are used namely the green epidermis, the bitter yellow sap (latex) and the non-bitter fleshy fillet (gel). The epidermis is rich in fibre. The bitter sap is rich in aloins and is known to have laxative, antibiotic and anti-fungal properties. The non-bitter fillet is nutritionally rich and contains water, amino acids, vitamins, polysaccharides, minerals and enzymes. Communal farmers prepare *A. ferox* concoction by crushing one leaf and adding it to a litre of drinking water. The concoction is provided until signs of disease are not seen (Mwale *et al*, 2005). This study was conducted to determine the socio-economic determinants that affect the use of *A. ferox* in addressing poultry health challenges and the extent at which farmers use it in communal chicken production.

3.2 Materials and methods

3.2.1 Ethical clearance

The experimental design and protocol of the study was approved by the University of Fort Hare Ethics Committee (Clearance number: NKU031SKAM01).

3.2.2 Study site

The survey was conducted in two villages (Mhlotsheni and Litshikini), in Mt Frere. Mt Frere (30°55'28" E; Altitude 1153m above sea level) is a town located in Alfred Nzo District Municipality in the North Eastern region of the Eastern Cape Province. Average rainfall in Mt Frere is 671mm per year with most of the rainfall falling during midsummer. Average summer minimum temperature is 18.3°C the average summer maximum temperature is 25.9°C. Average

winter minimum temperature is 3.7°C and average winter maximum temperature is 15.1°C. The area has a mountainous terrain which is suitable for crops and livestock production. Eighty three percent of households in Mt Frere own an average of 8 chickens (Aliber *et al.*, 2005). The literacy rate for the Alfred Nzo District is 55%.

3.2.3 Sampling procedure

Information on the medicinal plants used was collected from two randomly chosen villages in Mt Frere. A total of 53 respondents in both villages, were selected using the snowball sampling technique whereby key informants directed the interviewer to information-rich informants. Data collection was done by the help of trained enumerators.

3.2.4 Data collection

Data were collected by use of questionnaires from 53 respondents in September 2013. Three trained enumerators were used, one from the University of Fort Hare and one from each village where the study was conducted. The respondents were interviewed with permission from the local chiefs of the two villages. Each respondent signed a consent form before the interviews began. Information collected included: demography, livestock inventory, role of chickens, occurrence of chicken diseases and parasites, disease management and perception on the taste of meat treated with medicinal plants. The age ranges were according to Okoli *et al.* (2004). Data from the two villages were grouped for analysis.

3.2.5 Statistical analysis

Statistical analysis was done by using Proc Freq of SAS, 2003. The frequencies procedure was used to analyse frequencies of the socio-demographic data, chicken inventory, importance of

chickens, occurrence and control of diseases and parasites. The Chi square test of SAS (2003), was used to test the degree of association among demography, the occurrence and control of diseases and parasites and use of *A. ferox* in chicken production

3.3 Results and Discussion

3.3.1 Socio-demography

The social demographic background of respondents in the two villages is shown in Table 3.1. The study revealed that most of the respondents were females (86.8%). These results are concurrent with observations by Mwale and Masika (2009) and who reported that females who are involved in chicken production outnumber the males. This can be attributed to women's involvement in chicken production decreasing as the degree of intensification of poultry production increases (Gueye, 2003). The results also show that most of the respondents (34.7%) were in the 56-70 years age group and those between the ≤ 25 and 40 years had the least number of respondents combined (20.7%) (Figure 3.1). This implies that the younger generation is not actively involved in chicken production which can pose a challenge in sustainable chicken production in rural communities. In addition, the low literacy level in the two villages coupled with reliance on oral tradition as a way of passing on knowledge, threatens the loss of valuable indigenous information. This is shown by the majority of respondents having gone up to primary level (56.6%) and those who had never attended formal education constituted 24.5%. Likewise, the majority of respondents reported that their sources of knowledge pertaining to the use of *A. ferox* were from their local elders and parents (94.4%), and only 1.9% got their knowledge from literature. These results are in agreement with Masimba *et al.* (2011) and Moreki (2012) who

reported that the custodians of indigenous knowledge are the older men and women who then pass the knowledge to younger generations by word of mouth. It is therefore, crucial to document traditional practices in the communal areas so that information will be accessible to future generations.

Table 3.1: Demographic characteristics of communal farmers interviewed in Mt Frere, Eastern Cape

	Frequency	Percentage
Gender		
Male	7	13.2
Female	46	86.8
Age group(Years)		
≤25	4	7.5
26-40	7	13.2
41-55	11	20.8
56-70	20	37.7
>70	11	20.8
Level of Education		
Never attended school	13	24.5
Primary	30	56.6
Secondary	8	15.1
Tertiary	2	3.8
Source of Income		
Crops	2	3.8
Livestock	0	0
Salaries/Wages	4	7.5
Grant	47	88.7
Source of knowledge		
Family member (Mother or Father)	25	47.2
Other farmers	2	3.8
Read somewhere	1	1.8
Local village elders	25	47.2

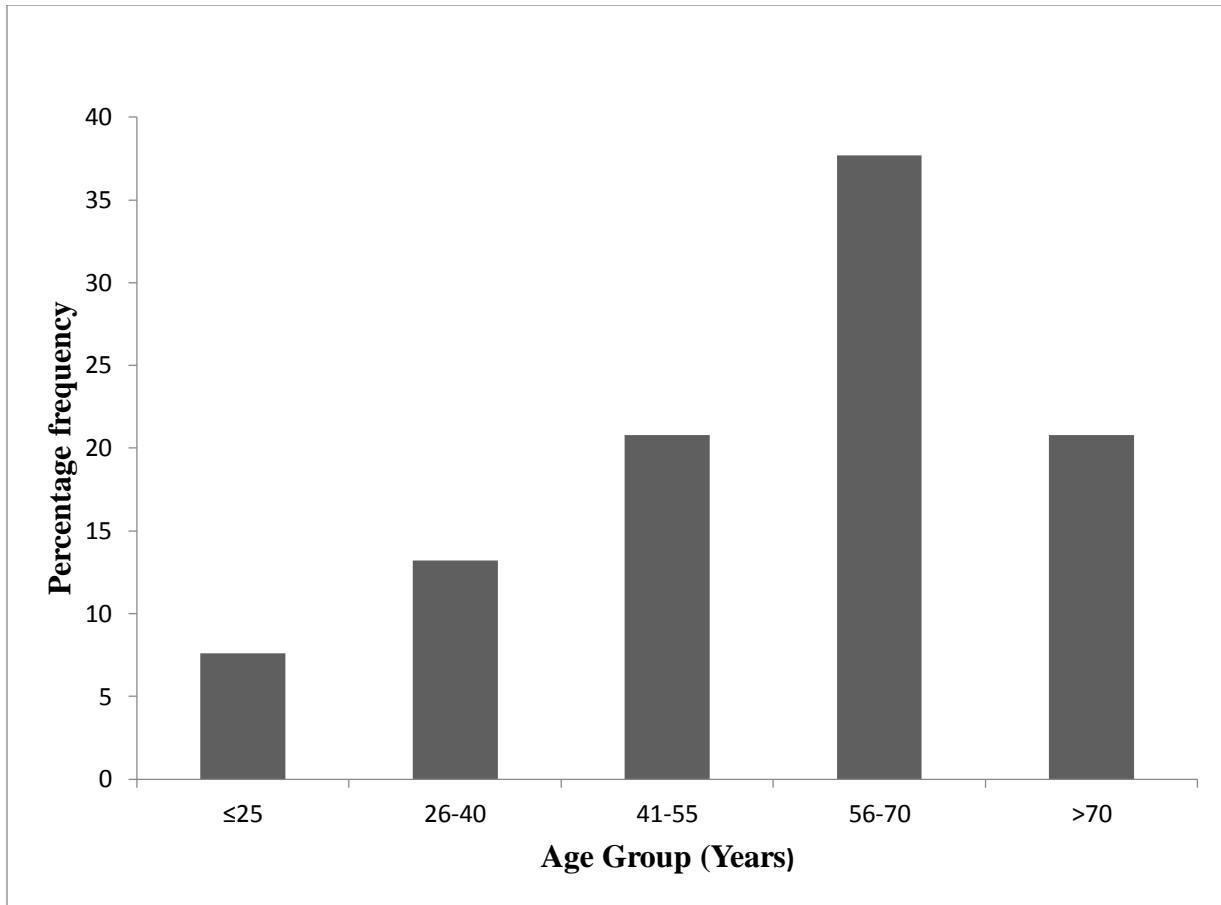


Figure 3.1: Age distribution of communal chicken farmers in villages of Mt Frere in Alfred Nzo Municipality, South Africa

The study also revealed that the majority of farmers (88.7%) relied on the government social grants and only 7.6% of the respondents earn income from formal employment. Similar results were reported by Mtileni *et al.* (2009) although the respondents who received wages (30%) were more and those who relied on social grants (47.3%) were less than the ones observed in this study.

3.3.2 Chicken inventory and their importance to communal farmers

The majority of respondents (34%) had flock sizes which ranged from 4-7 birds per household. This is in line with a report by Halima *et al.* (2007) who mentioned that the mean African household flock size is 7 chickens per household. Mwale *et al.* (2005) reported a lower average flock size of 3.8 in Mushagashe, Zimbabwe while the average flock size in Mopane district, Limpopo went as high as 17 chickens per household (Mtileni *et al.*, 2009). Swatson *et al.* (2001) emphasized the positive correlation between income and livestock numbers to be the major determinants of flock sizes.

All respondents reared indigenous chickens while 15.1% kept both indigenous chickens and broilers. The broilers were kept under free ranging conditions, similar to how the indigenous chickens were reared. Indigenous chickens were the most preferred option where resources were not available because they are hardy and resilient. Similar findings were reported by Nyaga (2007) and Kingori *et al.* (2010). However, Phiri *et al.* (2007) and Setlalekgomo (2012) suggested that indigenous chickens have low turnover, slow growth rate and low hatchability and this limits the number of chickens per household. In addition, predation and prevalence of diseases and parasites reduce the number of chickens at any given time (Halima *et al.*, 2007).

The importance of chickens in the two villages studied is shown in Table 3.2. The main reason for keeping chickens was for provision of both meat and eggs (96.2%). Rearing of chickens solely for meat was also ranked as very important by 84.9% of the respondents. Other studies conducted in the Eastern Cape, reported that 91.7% reared chickens for meat (Mwale and Masika, 2009). The above results confirm the role of chickens in food security. In addition, the current study revealed that 93.4% of the respondents regarded the rearing of chickens for eggs only as not important. However, eggs can play a role in poverty alleviation by contributing to income generation. Since chicken numbers are low in these communities, increasing the number of chickens per household can subsequently increase the number of eggs available such that the surplus will be sold for income generation (Smith *et al.*, 2013). In the current study, 73.6% indicated that keeping chickens for sell is not a priority. Some farmers in these communities also expressed their desire to rear chickens to sell but reported that they were constrained by low chicken numbers.

Chicken production for cultural purposes was insignificant in this study which is consistent with reports by Nyoni (2012) and Mwale and Masika (2009). Livestock species that are frequently used include goats (Webb and Mamabolo, 2004) and cattle (Bettencourt *et al.*, 2014). However, contrasting reports were found in KwaZulu Natal where chickens were kept mostly for the sole purpose of rituals (Naidoo, 2000). In Uganda, chickens were used as bride price (Amoki *et al.*, 2009) whereas in this study, 86.8% reported that keeping chickens for bride price is insignificant. A considerable number (52.8%) reported that they usually present chickens as gifts and this can be attributed to the farmers having no money to buy any other forms of gifts. Similar findings were reported in other parts of the Eastern Cape namely Centane district (Mwale and Masika,

Table 3.2: Priorities of keeping chickens in Mt Frere, Alfred Nzo Municipality, Eastern Cape

Parameters	Ranking			
	High	Medium	Low	Not Important
Consumption				
Meat and eggs	96.2	0	0	3.8
Meat only	84.9	7.5	1.9	5.7
Eggs only	3.8	1.9	0	94.3
Social				
Gifts	13.2	52.8	20.8	13.2
Cultural				
Bride wealth	0	1.9	11.3	86.8
Installation of ancestors	7.5	34	7.5	51.0
Income				
Selling live chickens	7.5	7.6	11.3	73.6

2009) and Amatola basin (Nyoni and Masika, 2012). In this regard, Moreki *et al.* (2010) reported that chickens are kept in rural areas as a form of insurance for emergency cash needs.

3.3.3 Occurrence diseases and parasites

Majority of farmers (84.6%) reported that they had problems with chicken diseases and parasites namely respiratory distress, coccidiosis, external parasites, Newcastle and helminths. Problems associated with chicken diseases and parasites were consistent with findings in Uganda where 91% of households had diseased chickens (Amoki *et al.*, 2009). In South Africa, similar findings were reported in Qwa Qwa district in the Free State region where all chickens sampled were found to be diseased (Thekiso *et al.*, 2003). Village chickens are kept under free range conditions with little biosecurity measures where they are susceptible to infection. Diseases and parasites are also prevalent in tropical regions where temperatures encourage the breeding and spread of pathogens and parasites (Phiri, 2007).

According to the signs, farmers perceived major diseases and conditions affecting chickens in this study to be Newcastle disease, Coccidiosis, respiratory distress and worm infestation (Figure 3.2). The majority of respondents (69.2%) perceived their birds to be affected by respiratory problems presented by gasping, nasal congestion, watery eyes, coughing and sneezing. The signs above are consistent with Infectious bronchitis and chronic respiratory disease (Okitoi *et al.*, 2007). These findings corroborate those from Zimbabwe (Kelly *et al.*, 1994; Masimba *et al.*, 2011) and Kgatleng District, Botswana (Mushi *et al.*, 2006). High perceived incidences of respiratory distress could indicate the infectious nature of the condition and could be facilitated by high interaction of village chickens with wild birds which is facilitated by low levels of biosecurity.

Newcastle disease signs reported included greenish diarrhoea, droopy wings, inappetence, difficulty in breathing, sneezing, twisted neck, paralysis and sudden death. A considerable number of respondents (60%) reported that their chickens showed signs of Newcastle disease and among these 65.2% reported that incidences of death in chickens showing signs of Newcastle were most prevalent. Similar results were reported in KwaZulu Natal (Swatson *et al.*, 2001) and in an inter-provincial study covering Limpopo, Northern Cape and Eastern Cape (Mtileni *et al.*, 2009) where Newcastle disease was a major concern as perceived by the farmers. High rate of mortality due to Newcastle disease concurs with Thekiso *et al.* (2003), who reported an 80-100% chicken mortality due to Newcastle in the Free State. The high incidences of Newcastle infections and deaths can be attributed to the lack of vaccination programmes in the rural areas (Spradbrow, 1993/4). The mortality of older birds due to Newcastle was perceived by the farmers to be higher (65.4%) than chick mortality (15.4%). Permin and Pedersen (2002) mentioned that Newcastle is mostly observed in growers and adult chickens. Contrasting results were reported in Thailand by Thitisak *et al.* (1989) where mortality of chicks due to Newcastle was higher (4.1%) than older birds (2.1%).

Coccidiosis characterised by bloody diarrhoea, emaciation, droopy wings, ruffled feathers and poor growth, was reported by 61.5% of the respondents. Similar findings were observed by Mwale *et al.* (2005) who reported that 90.5% of respondents in Mushagashe, Zimbabwe claimed that their chickens had Coccidiosis. Although the results in this study were not confirmed by serology, prevalence of Coccidiosis in rural areas can be attributed to poor biosecurity measures and lack of coccidiostats in the feed that is available to the chickens (Sharma *et al.*, 2013).

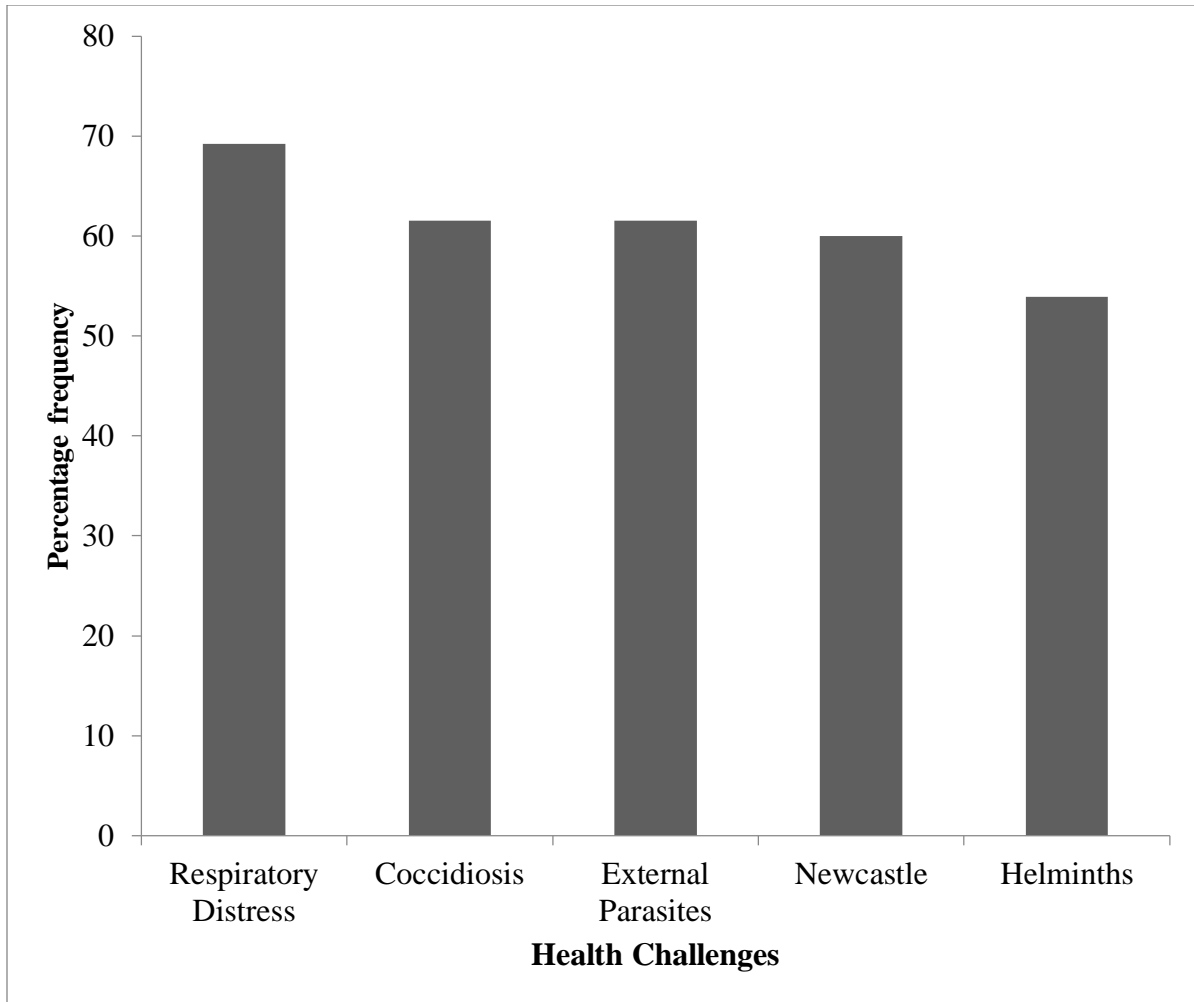


Figure 3.2: Frequency of chicken health challenges as reported by respondents in Mt Frere, Eastern Cape

The proportions of farmers who claimed to have problems with external parasites and helminths in their chickens were 61.5% and 53.9%, respectively. These results contrast with Mwale and Masika (2009) and Njuga (2003) who found internal parasites to be more prevalent than external parasites. High prevalence of parasitic infestation is common in extensive management systems where chickens rely on the environment for food and shelter (Muchadeyi *et al.* 2007). Parasitic infestation can translate into low household flock sizes because the discomfort which accompanies parasitic infestation distracts hens from incubating and this affects hatchability (Nyoni and Masika, 2012).

3.3.4 Control of chicken diseases and parasites

The majority of farmers (53.9%) used traditional methods of treating diseases and controlling parasites while 42.3% preferred using commercial drugs. A small proportion of farmers (3.9%) used both traditional remedies and commercial drugs. These results were concurrent with studies conducted in the North-East Free State and Centane District, in the Eastern Cape (Thekiso *et al.*, 2003; Mwale and Masika, 2009) where the majority of respondents preferred using traditional remedies. Likewise, Masimba *et al.* (2011) reported that only 5% of the respondents in Zimbabwe used both traditional remedies and commercial drugs. The study also revealed that the choice of medicine (traditional or commercial) was affected ($P < 0.05$) by the level of education and income. The findings of this study are in agreement with Mafimisebi *et al.* (2012) who affirmed that the higher the income, the lower the utilization of traditional remedies particularly medicinal plants. Contradicting observations were reported by Mwale and Masika (2009) who argued that there was no relationship between level of education and use of traditional medicines. However, a study by Kiringe (2005) revealed that farmers preferred using traditional remedies irregardless of their socio-economic status whereas the results of this study

imply that improvement in the farmers' socio-economic status will make them to choose commercial drugs over traditional medicine.

Although the majority of farmers used traditional medicine, many of them (57.7%) were of the opinion that conventional medicines were more effective. In contrast, previous studies by Mwale and Masika (2009) revealed that 96.9% of rural farmers in Centane perceive traditional medicine to be more effective than commercial drugs. The perceived ineffectiveness of traditional remedies may be due to misdiagnosis by the farmers because of poor knowledge of poultry diseases (Mwale *et al.*, 2005; Masimba *et al.*, 2011). Another reason could be that the exact dosages that ensure effectiveness of the medicine, are not known hence cannot be standardized (Mussarat *et al.*, 2014).

Among those who use traditional remedies, *A. ferox* was the plant of choice (96.2%) in the treatment of chicken diseases and control of parasites. The dense geographical distribution of *A. ferox* in Mt Frere makes it locally available and easily accessible to the farmers. It is also favoured since it is a perennial plant hence it is available all year round (Masimba *et al.*, 2011). All the respondents also claimed that *A. ferox* had no side effects and this is in agreement with Mwale *et al.* (2005). The same author also reported that Aloe was easy to prepare and this agrees with the current study. It is prepared by cutting a leaf and mixing it with drinking water (Mwale and Masika, 2009; Masimba *et al.*, 2011). The use of *A. ferox* can also be accredited to the fact that it can be used to treat a wide spectrum of diseases/ signs of diseases for instance Coccidiosis, Newcastle Disease, coughing, loss of appetite and helminthosis (Ibrahim *et al.*, 1984; Masika and Afolayan, 2002; Gadzirayi *et al.*, 2005; Okitoi *et al.*, 2007; van Wyk, 2013). In this study, the ailments which the respondents treat using *A. ferox* are shown on Table 3.3.

Table 3.3: Percentage frequency of respondents who use *Aloe ferox* for specific chicken ailments in Mt Frere

Disease or condition	Frequency (%)
Diarrhoea (watery, bloody, greenish, whitish)	88.7
Gasping, coughing, nasal congestion, watery eyes	75.5
Anaemia and Worm infestation	73.6

3.4 Conclusion

Chickens, as revealed by this study, played important roles in ensuring livelihoods, gender equity, food security and potential income generation. However, low literacy levels and low income in the two villages encouraged the use of *A. ferox* which was available locally at no cost and was easy to prepare for medicinal purposes. *Aloe ferox* was widely used to treat and/or control diseases and parasites including Newcastle, coccidiosis, respiratory problems and helminths. Further serology studies need to be conducted to confirm the farmers' perception on the disease situation in Mt Frere.

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Chapter 4: Effects of *Aloe ferox* used in phytotherapy on growth performance, carcass yield, organ weights and blood parameters of broilers

Abstract

The study was done to determine the effects of *Aloe ferox*, used in the treatment of chicken diseases and parasites, on growth performance, carcass yield and relative organ weights of broilers. A total of 600 Ross 308 day-old broilers, were randomly put in 6 treatment groups with 4 replicates, with each treatment having 100 birds. Fresh aqueous *A. ferox* leaf juice (ALJ) was administered in drinking water at a dosage of 20ml/litre to T₁, T₂ and T₃ from day one to day 35, day one to day 14 and day 15 to day 28, respectively. Birds in T₄ and T₅ (positive controls) were treated with terramycin at the recommended dosage of 14g/litre of drinking water from day one to day 6 and from day 15 to 20, respectively; and birds in T₆ (negative control) received distilled water from day 1 to 35. Body weight (BW), Average Daily Gain (ADG), Feed Intake (FI) and Feed Conversion Ratio (FCR) were recorded weekly to determine growth performance. Carcass yield was determined by the dressing percentage (DP) and relative organ weights (ROW). The birds that were given *A. ferox* for the first two weeks (T₂) consumed significantly ($P<0.05$) more feed (189.4g) than the negative control (159.6g) in the beginning of the starter phase. Subsequently, their ADG recorded on day 7 (27.1g) and day 14 (43.1g) were significantly higher than the negative control (22.8g and 36.2g, respectively). On day 21, birds in T₂ also had significantly larger (476.9g) ABW as compared to the negative control (427.4g). Significant treatment effects ($P<0.05$) for FCR were reported in the 4th week for the birds that received *A. ferox* throughout (T₁: 3.5) and those that received terramycin in the beginning of the production cycle (T₄: 2.7). No significant treatment effects ($P<0.05$) were reported for dressing percentage and relative organ weights. Birds which were given *A. ferox* during the first two weeks of the

production cycle (T₂) yielded the highest high density lipoprotein (HDL) cholesterol values (2.78 mmol/L) and T₃ had the lowest values (0.61mmol/L) for low density lipoprotein (LDL) cholesterol. In conclusion, administering *A. ferox* continuously in the beginning of the cycle resulted in significantly better performance as compared to administering it in the middle and throughout the cycle. Generally, no significant differences were found among the birds that received *A. ferox* and those that received terramycin and this shows that *A. ferox* inclusion results in performance that is comparable to antibiotic treatments.

Keywords: *Aloe ferox*, broilers, growth performance, carcass characteristics, blood biochemistry

4.1 Introduction

Broiler breeds have undergone years of selection for their traits of economic importance particularly high meat yield and growth rate. Genetic selection for growth performance has also been accompanied by an increase in the feed conversion efficiency (Zuidhof *et al.*, 2006). Introduction of Antibiotic Growth Promoters (AGPs) contributed to the increase in growth rate of modern strains of broilers. However, challenges pertaining to some parts of the body growing at different rates, have been noted and this leads to leg disorders (Knowles *et al.*, 2008; Dawkins and Layton, 2012), cardiovascular diseases and sudden mortality (Julian, 2005).

The use of antibiotics in livestock production is of paramount importance. They can be used for growth promotion and also for treatment and prevention of diseases and parasites. In small concentrations (2.5-50ppm) stretched over a long period, antibiotics increase Average Daily Gain (ADG) by 1-10% (Prescott and Baggot, 1993; Hashemi and Davoodi, 2011) and hence profitability of intensive broiler production (Huyghebaert *et al.*, 2011). On the other hand, antibiotics used over a long period of time have been reported to cause resistance of local

bacterial populations hence allowing survival and selection of antibiotic resistant microbes (Davidović *et al.*, 2009). This encourages zoonotic diseases to be passed on from broilers to humans through consumption of infected meat. Reports of reduction in salmonellosis in humans have been made in Denmark after the ban of AGPs in 1998 (WHO, 2003). However, with increase in consumer demand for chicken, alternatives of antibiotics need to be established so as to ensure optimum production of poultry meat.

The increase in demand of poultry meat has also probed chicken production to be encouraged in rural areas where food security issues are critical. Rural farmers are faced with biosecurity challenges coupled with inaccessibility to commercial drugs which increase the incidences of chicken diseases and parasites. Consequently, they resort to phytotherapy using plants that are cheap, locally available and have undergone years of trials (Anthony *et al.*, 2005; Chapter 3). On the other hand, the use of phytogetic agents has gained importance among animal scientist, although more research needs to be done to determine their mode of action (Fulton *et al.*, 2002). Phytogetic products are reported to be residue free, having no side effects and being biodegradable (Hashemi *et al.*, 2008). Rural farmers widely use medicinal plants on both broilers and indigenous chickens although the implications of these medicinal plants on growth performance and meat quality are not known (Chapter 3).

One of the plants that can be considered is *Aloe ferox*. It has been traditionally used in chicken production for health promoting purposes since the first century AD (Bolu, *et al.*, 2013; Chapter 3). Afolayan *et al.* (2002) reported significant activity of *A. ferox* against bacteria and fungi. Furthermore, observations by McDaniels *et al.* (1990) showed its antiviral activity. Approximately, 130 bioactive compounds have been isolated from *A. ferox* (Kambizi *et al.*, 2004). Classes of phytochemicals present in *A. ferox* include anthraquinones, chromones,

anthrone-C-glycosides and polyphenols (Chen *et al.*, 2011). Compounds like aloe emodin, chrysophanol and aloin A have antibacterial activity (Kambizi *et al.*, 2004) and those with nutritional value include amino acids, glucoproteins, vitamins, polysaccharides, sterols, saponins and phenolic compounds (Alessandro and Stefano, 2005; Chen *et al.*, 2011; Bhaludra *et al.*, 2013).

Phytogenic compounds may have influence in blood biochemistry. For example, phenolic compounds found in phytogenic agents, when included in broiler diets may have hypocholesterolemic effects (Daneshayar *et al.*, 2011). Blood parameters are important in that they are major indicators of physiological, pathological and nutritional status of an organism. Hence, the influence of *A. ferox* on blood biochemistry can be used to assess the safety of plant extracts on animal health.

In rural areas, *A. ferox* has been reported to be administered to birds regardless of their age (Mwale *et al.*, 2005). At the same time, other scholars have reported that phytochemicals in plants of the genus *Aloe* are reported to improve feed intake and feed conversion efficiency and this influences weight gain in chickens (Darabighane *et al.*, 2011; Singh *et al.*, 2013; Doley *et al.*, 2014). Little work has been done to determine the effects of *A. ferox* on broiler traits of economic importance such as growth performance, carcass characteristics and blood biochemistry. Therefore, this research was conducted to determine the effect of medicinal dosage of *A. ferox* administered at different phases of the production cycle on body weight, average daily gain, feed intake, feed conversion ratio, dressing percentage, organ weights and blood biochemical parameters of broilers.

4.2 Materials and methods

4.2.1 Ethical clearance

The experimental design and protocol of the study was approved by the University of Fort Hare Ethics Committee (Clearance number: NKU031SKAM01).

4.2.2 Description of study site

The experiment was conducted at Fort Cox Agricultural College situated 36°46'23"S and 027°02'15"E. The altitude of Fort Cox College is 552m above sea level. It receives approximately 500mm of rainfall per annum. Average minimum and maximum temperatures are 12.3°C and 23.8°C.

4.2.3 Animals and housing

Six hundred unsexed Ross-380 broilers were kept under a completely randomized design from day old to 35 days in deep litter production system. The flock was divided into 6 treatment groups, each with 4 replicates (100 birds per treatment). Standard management conditions were provided for the birds during the 6 week production cycle. The birds were housed in a single facility with uniform conditions. The house was disinfected and the floor was covered with a 5cm depth of wood shavings prior to occupation. Lighting was given continuously and ventilation was controlled depending on prevailing weather conditions. The birds were vaccinated at the hatchery against Fowl pox and Marek's disease. However, no vaccination programmes were done at the farm. Mortality was recorded as they occurred. Management of birds were in accordance with the principles of animal care in experimentation (NRC, 1985). The treatments were formulated and administered as shown in Table 4.1. The groups T₄ and T₅ (Positive controls) were treated with terramycin (Active ingredient: Oxytetracycline hydrochloride 55mg/g; Manufacturer: Zoetis) at a recommended dosage of 14g/litre of drinking

water from day 1- 6 and from day 15- 20, respectively. T₆ (negative control) received distilled water from day 1-35.

4.2.4 Diets

The birds were fed with Epol Optigro© starter (1-21d) and finisher (22-35d). Water and feed were given *ad libitum*. *Aloe ferox* leaves were harvested from Fort Cox Agricultural College. Fresh *A. ferox* leaf juice was prepared using a blender, daily.

4.2.5 Determination of Growth performance

Growth performance of the flock was determined by Feed Intake (FI) and Feed Conversion Ratio (FCR), Average Daily Gain (ADG) and Body Weight (BW). Weight of the birds per group was recorded at placement and weekly thereafter. Weight was measured at 8.00 am before feeding after which ADG were calculated as follows:

$$\text{BWG (g)} = (\text{Final weight} - \text{Initial weight}) / \text{Number of birds per pen}$$

$$\text{ADG (g)} = \text{Average Body Weight Gain} / 7 \text{ days}$$

Feed was also allocated weekly per pen and as such FI and FCR (corrected for mortality) were calculated as follows:

$$\text{FI (kg)} = (\text{Feed allocated per pen} - \text{Refusal}) / \text{Number of Birds per pen}$$

$$\text{FCR} = \text{Feed intake} / \text{Body Weight Gain.}$$

Table 4.1: Experimental design showing the allocation of *Aloe ferox*, terramycin and distilled water during the 35 day trial

Age (weeks)	Treatments					
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆
1	A	A		T		
2	A	A				
3	A		A		T	
4	A		A			
5	A					

A-*Aloe ferox* whole leaf juice (ALJ) administered at 20ml/l of drinking water

T- Terramycin administered at 14g/l of drinking water

T₁- ALJ administered throughout the production

T₂- ALJ administered during the first two weeks of the production cycle

T₃- ALJ administered in the third and fourth week of the production cycle

T₄- Terramycin administered at the beginning of the production cycle

T₅- Terramycin administered in the middle of the production cycle

T₆- Distilled water administered throughout the production cycle

4.2.6 Blood biochemistry

Two birds per replicate, were randomly chosen and their individual live weights shortly before slaughter were recorded (Slaughter Weight). Prior to slaughter, the birds were fasted for 8 hours with water being provided *ad libitum*. Electrical stunning (240V, 20A, 50Hz) was done to depress the central nervous system of the birds and to increase their heartbeat so as to ensure faster and complete bleeding (Raj, 1998). Their throats were then cut using a sharp knife.

Blood samples were collected during exsanguination into 5ml tubes with no anticoagulant for determination of serum biochemical parameters. Plasma was separated by centrifuging the samples for 10 min at 3550 rpm using a centrifuge (Model: 5403, Gatenbay Eppendorf GmbH, Engelsdorp, Germany), after which the serum samples were stored at -20°C. The serum samples were then sent to the National Health Laboratory Services (NHLS), Port Elizabeth and serum biochemistry was determined using the Beckman Coulter DXC 600, Chemistry Analyser (Ireland). Serum biochemical parameters analysed were uric acid, total protein, albumin, cholesterol, triglycerides, total cholesterol, high density lipoprotein (HDL) cholesterol, low density lipoprotein (LDL) cholesterol and glucose.

4.2.7 Carcass weights and organ weights

After cutting the throat, scalding was done using a water bath fixed at 53°C for 1.5 minutes. A one drum plucker (Rotamaster, RSA) was used to pluck for 30 seconds each cycle. The carcasses were then washed followed by evisceration. Individually weighing of the liver, heart and gizzard was done and their weights were recorded as a percentage of slaughter weight. After removal of visceral organs, the head and legs below the knee, the individual carcasses were weighed. Relative organ weights and dressing percentages were calculated using the following:

Relative Organ Weight = weight of organ/ slaughter weight * 100

Dressing Percentage = carcass weight / slaughter weight * 100

4.2.8 Statistical analysis

Data were analysed using one way analysis of variance (ANOVA) of the General Linear Model Procedure (Proc GLM) repeated measures of SAS (2003). Comparisons of means were done by use of the Least Significant Difference Test where $P < 0.05$ was considered to be statistically significant. The statistical model was as follows:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where Y_{ij} = Response variable (BW, ADG, FI, FCR, Organ Weights, Dressing Percentage);

μ = Overall mean

T_i = Treatment effect

e_{ij} = Random error

4.3 Results and discussion

4.3.1 Growth performance

Tables 4.2-5 show the effect of *Aloe ferox* and terramycin on broiler Feed Intake (FI), Average Daily Gain (ADG), Body weight (BWG) and Feed Conversion Ratio (FCR). Treatment effects ($P < 0.05$) on feed intake were noted on day 7 where the birds in T_2 consumed significantly more feed (189.4g) than the negative control (159.6g) (Table 4.2). Although no significant differences were found in the subsequent days after day 7, groups that received *A. ferox* (T_1 , T_2 and T_3) had numerically higher feed intake values as compared to the groups that received terramycin (T_4 and

T₅) and distilled water (T₆). These results are in agreement with Windsch *et al.* (2009) who mentioned that *Aloe spp.* change taste of drinking water and also stimulates appetite resulting in increased feed intake. In addition, *Aloe spp.* contains folic acid (Vitamin B₉) which encourages secretion of digestive juices thereby influencing feed consumption (Sahin *et al.*, 2003). However, a study by Hassanbeigy-Lakeh *et al.* (2012) revealed no significant effect of *Aloe spp.* administered to broilers in drinking water throughout the experimental period. Comparisons of means for the groups treated with *A. ferox* in this study, showed that the group that received *A. ferox* during week 1 and 2, generally performed better than its *A. ferox* counterparts.

Significant treatment effects ($P < 0.05$) were found for ADG from day 1-7 and 8-14 (Table 4.3). The negative control had significantly ($P < 0.05$) lower (22.8g) ADG than T₂ (27.1g) from day 1-7. The same can be noted from day 8-14 where T₂ (43.1g) and T₄ (43.2g) had significantly higher ($P < 0.05$) ADG than the negative control (36.2). However, no significant differences ($P > 0.05$) were found between the *A. ferox* and terramycin groups. This concurs with the study by Darabighane *et al.* (2011) who also reported increased ADG and weekly body weight gains of broilers treated with *Aloe sp.* This might have been a result of polysaccharides like acemannan found in the *A. ferox* crude extracts, which induce immunomodulation and subsequently increase the health status of the birds. Consequently, an increase in health status of the birds will increase ADG (Xue and Meng, 1996; Djeraba and Quere, 2000). *Aloe ferox* also contains different vitamins, minerals, organic acids and carbohydrates which work synergistically to enhance ADG (Boudreau and Beland, 2006). Likewise, antibiotics indirectly increase ADG by reducing the colonization of pathogenic and non-pathogenic bacteria which improves the health status of the birds (Ferket, 2004).

Table 4.2: Effect of inclusion of *Aloe ferox* in drinking water on Feed Intake (g) of broilers

Age (days)	Treatments						SEM
	T ₁ (g)	T ₂ (g)	T ₃ (g)	T ₄ (g)	T ₅ (g)	T ₆ (g)	
7	168.6 ^{ab}	189.4 ^a	176.8 ^{ab}	175.4 ^{ab}	173.5 ^{ab}	159.6 ^b	9.68
14	472.9	467.9	472.6	448.5	470.1	474.2	23.46
21	772.5	804.1	760.3	752.4	768.6	778.5	29.06
28	1099.3	1030.8	1013.5	976.7	1000.2	993.4	59.16
35	1444.3	1504.6	1319.4	1455.5	1360.1	1308.2	70.53

^{ab} Means within the same row that do not share a common superscript significantly different (P<0.05) from each other. SEM = Standard Error of Means

T₁- *Aloe ferox* whole leaf juice administered throughout the production

T₂- *Aloe ferox* whole leaf juice administered during the first two weeks of the production cycle

T₃- *Aloe ferox* whole leaf juice administered in the third and fourth week of the production cycle

T₄- Terramycin administered at the beginning of the production cycle

T₅- Terramycin administered in the middle of the production cycle

T₆- Distilled water administered throughout the production cycle

Tables 4.3: Effect of inclusion of *Aloe ferox* in drinking water on Average Daily Gain (g/d) of broilers

Age (days)	Treatments						SEM
	T ₁ (g/day)	T ₂ (g/day)	T ₃ (g/day)	T ₄ (g/day)	T ₅ (g/day)	T ₆ (g/day)	
1-7	25.3 ^{ab}	27.1 ^a	24.1 ^{ab}	25.1 ^{ab}	24.8 ^{ab}	22.8 ^b	1.38
8-14	39.7 ^{ab}	43.1 ^a	39.7 ^{ab}	43.2 ^a	40.5 ^{ab}	36.2 ^b	2.43
15-21	45.3	50.6	49.9	50.3	47.6	42.9	2.91
22-28	65.8	61.3	63.5	63.1	66.0	64.9	4.70
29-35	97.9	85.9	89.0	75.4	85.4	88.7	7.94

^{ab} Means within the same row that do not share a common superscript significantly different (P<0.05) from each other. SEM = Standard Error of Means

T₁- *Aloe ferox* whole leaf juice administered throughout the production

T₂- *Aloe ferox* whole leaf juice administered during the first two weeks of the production cycle

T₃- *Aloe ferox* whole leaf juice administered in the third and fourth week of the production cycle

T₄- Terramycin administered at the beginning of the production cycle

T₅- Terramycin administered in the middle of the production cycle

T₆- Distilled water administered throughout the production cycle

Significant treatment effect ($P < 0.05$) on body weight due to the inclusion of *A. ferox* was found from day 15-21 and 22-28 (Table 4.4). The study also revealed that T₄ had larger BW throughout the cycle. This is concurrent with a study by Sharifi *et al.* (2013), where antibiotics were reported to have superior growth promoting effects. In addition, Bolu *et al.* (2013) reported higher weight gain of antibiotic treatment groups in comparison with those treated with 20ml/l *A. vera*. However, in the latter study, increasing the *A. vera* treatment to 30ml/l resulted in an increase in BW. Therefore, in this study lower BW of *A. ferox* treatments in contrast with antibiotic treatment could be attributed to lower concentration of active compounds in Aloe at a dosage of 20ml/l. No significant differences ($P > 0.05$) in BW were found between the treatments that received terramycin (T₄) and *A. ferox*. This might be because *A. ferox*, like terramycin, has antibacterial properties which increase the health status of the birds and also control growth and colonization of pathogenic and non-pathogenic intestinal microflora (Ferket, 2004).

Significant treatment effects ($P < 0.05$) were found for feed conversion ratio during the second and fourth week (Table 4.5). During the second week, differences were found between the positive T₄ (1.4) and negative T₆ (2.1) controls. During the fourth week, T₁ and T₅ (3.5 and 3.4, respectively) had significantly elevated FCRs as compared to the positive control, T₄ (2.7). Feed conversion ratio was generally lower in T₄ showing that administering antibiotics at the beginning of the production cycle, results in better utilization of feed. These findings are in agreement with Ni and Piao (2012) who reported that antibiotics in the starter phase result in greatest economic benefit. Administering antibiotics to starter broilers improves gut morphology by increasing villus height hence encourages absorption of nutrients (Baurhoo *et al.*, 2007).

Table 4.4: Effect of inclusion of *Aloe ferox* in drinking water on Body Weight (g) of broilers

Age (days)	Treatments						SEM
	T ₁ (g)	T ₂ (g)	T ₃ (g)	T ₄ (g)	T ₅ (g)	T ₆ (g)	
7	43.6	39.0	42.9	45.3	43.4	41.7	2.29
14	169.1	166.3	174.8	176.5	171.4	169.4	5.53
21	447.6 ^{ab}	476.9 ^a	463.0 ^{ab}	487.5 ^a	466.7 ^{ab}	427.4 ^b	16.56
28	908.4 ^{ab}	906.1 ^{ab}	907.3 ^{ab}	939.5 ^a	929.0 ^{ab}	881.5 ^b	17.51
35	1225.8	1260.0	1256.5	1291.5	1229.7	1214.5	29.05

^{ab} Means within the same row that do not share a common superscript are significantly different (P<0.05) from each other. SEM = Standard Error of Means

T₁- *Aloe ferox* whole leaf juice administered throughout the production

T₂- *Aloe ferox* whole leaf juice administered during the first two weeks of the production cycle

T₃- *Aloe ferox* whole leaf juice administered in the third and fourth week of the production cycle

T₄- Terramycin administered at the beginning of the production cycle

T₅- Terramycin administered in the middle of the production cycle

T₆- Distilled water administered throughout the production cycle

Table 4.5: Effect of inclusion of *Aloe ferox* in drinking water on Feed Conversion Ratio (g:g) of broilers

Age (days)	Treatments						SEM
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	
1-7	1.4	1.5	1.3	1.3	1.3	1.2	0.08
8-14	1.7 ^{ab}	1.5 ^{ab}	1.6 ^{ab}	1.4 ^a	1.6 ^{ab}	2.1 ^b	0.11
15-21	1.6	1.8	1.7	1.7	1.6	1.7	0.13
22-28	3.5 ^a	2.9 ^{ab}	2.9 ^{ab}	2.7 ^b	3.4 ^a	3.1 ^{ab}	0.33
29-35	2.3	2.3	2.2	2.2	2.6	2.6	0.22

^{ab} Means within the same row that do not share a common superscripts are significantly different (P>0.05) from each other. SEM = Standard Error of Means

T₁- *Aloe ferox* whole leaf juice administered throughout the production

T₂- *Aloe ferox* whole leaf juice administered during the first two weeks of the production cycle

T₃- *Aloe ferox* whole leaf juice administered in the third and fourth week of the production cycle

T₄- Terramycin administered at the beginning of the production cycle

T₅- Terramycin administered in the middle of the production cycle

T₆- Distilled water administered throughout the production cycle

This study has shown that administering *A. ferox* in drinking water throughout the production cycle results in higher FCR. This can be attributed to the cumulative effects of saponins, tannic acid, phytate and oxalate, which are anti-nutritional factors that depress feed utilization in the body (Onu, 2012; Adesuyi, *et al.*, 2012). Tannins precipitate with iron and other metals preventing their absorption into the bloodstream (Akande *et al.*, 2010). The same author also mentioned that, oxalate binds with proteins forming complexes which reduce protein digestion. Phytate chelates calcium, zinc and other minerals preventing their absorption (Adesuyi *et al.*, 2012). The implications of the continuous use of *A. ferox* in a broiler enterprise could reduce profitability resulting from the inefficient use of feed. Although there were no significant variations across the *A. ferox* treatments, T₃ had the lowest mean (2.2) from day 29-35. Other studies have shown that medicinal plants affect FCR by reducing gut microflora which reduces competition for nutrients with the host and also improves absorption of nutrients into the blood stream (Windsch *et al.*, 2008; Hashemi and Davoodi, 2010; Darabighane and Nahashon, 2014). Hence, this shows that *A. ferox* could have been efficient in reducing gut microflora when administered from day 15-21 (T₃).

4.3.2 Carcass yield and Organ Weights

Aloe ferox groups exhibited numerically higher dressing percentage although no significant treatment effects ($P>0.05$) were observed among the groups (Table 4.6). Contrasting results were reported by Darabighane *et al.* (2011) whereby antibiotic group showed higher dressing percentage as compared to the *Aloe spp.* group. Sharifi *et al.* (2013) and Singh *et al.* (2013) reported no significant treatment effects on eviscerated carcass yield and this collaborates the findings of this study. However, T₁ and T₃ recorded the highest dressing percentage (75.2%)

showing that administering *A. ferox* in drinking water throughout the production cycle, yields numerically the same yield as administering it from the third week.

There were no significant differences ($P>0.05$) in percentage organ weights among the *A. ferox* groups and the controls (Table 4.7). The eviscerated organ weights in question were the heart, liver and the gizzard. Findings of this study were affirmed with studies by Durrani *et al.* (2008), Sharifi *et al.* (2013) and Hernandez *et al.* (2004), who reported no treatment effects of plant extracts and controls on eviscerated organ weights. The physiological explanation to this is not clear and further investigations are required on this aspect.

4.3.3 Blood biochemistry

The effect of *A. ferox*, terramycin and distilled water on blood biochemistry is shown in Table 4.8. The results show that there were no significant treatment effects ($P>0.05$) on uric acid (UA), total protein (TP), cholesterol, triglycerides and glucose. These results support work done by other scholars that reported no significant effect of *Aloe spp.* on glucose (Ognik and Merska, 2012; Bolu *et al.*, 2013), triglycerides (Ognik and Merska, 2012), uric acid (Bolu *et al.*, 2013; Mehala *et al.*, 2008) and total protein (Singh *et al.*, 2013). Although many scholars reported no significant differences in some serum biochemical parameters, there are reports which found significantly higher plasma glucose (Singh *et al.*, 2013) and lower cholesterol concentration (Bolu *et al.*, 2013) in the birds that received 20ml/l *A. vera* leaf juice in drinking water.

The present study showed significant treatment effects ($P<0.05$) on High Density Lipoproteins (HDL) cholesterol and Low Density Lipoproteins (LDL) cholesterol. Inclusion of *A. ferox* in the first two weeks of the production cycle yielded the highest values (2.78 mmol/L) for HDL cholesterol in this study. Furthermore, inclusion of *A. ferox* from the third week of the production

Table 4.6: Effect of inclusion of *Aloe ferox* in drinking water on Dressing Percentage of broilers

Treatments	Dressing percentage
T₁	75.2
T₂	73.0
T₃	75.2
T₄	71.9
T₅	71.8
T₆	70.8
SEM	1.86

SEM=Standard Error of Means

T₁- *Aloe ferox* whole leaf juice administered throughout the production

T₂- *Aloe ferox* whole leaf juice administered during the first two weeks of the production cycle

T₃- *Aloe ferox* whole leaf juice administered in the third and fourth week of the production cycle

T₄- Terramycin administered at the beginning of the production cycle

T₅- Terramycin administered in the middle of the production cycle

T₆- Distilled water administered throughout the production cycle

Table 4.7: Effect of inclusion of *Aloe ferox* in drinking water on Relative Organ Weights (%) of broilers

Treatment	Least Squares Means		
	Heart	Liver	Gizzard
T ₁	0.57	1.97	2.03
T ₂	0.59	2.23	2.19
T ₃	0.58	2.34	2.42
T ₄	0.59	2.19	2.13
T ₅	0.60	2.00	2.31
T ₆	0.57	2.21	2.27
SEM	0.04	0.20	0.18

SEM=Standard Error of Means

T₁- *Aloe ferox* whole leaf juice administered throughout the production

T₂- *Aloe ferox* whole leaf juice administered during the first two weeks of the production cycle

T₃- *Aloe ferox* whole leaf juice administered in the third and fourth week of the production cycle

T₄- Terramycin administered at the beginning of the production cycle

T₅- Terramycin administered in the middle of the production cycle

T₆- Distilled water administered throughout the production cycle

Table 4.8: Effect of inclusion of *Aloe ferox* in drinking water on Blood biochemical parameters of broilers.

Blood parameter (mmol/L)	Treatment					
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆
Uric acid	0.33±0.043	0.27±0.043	0.25±0.050	0.30±0.043	0.34±0.043	0.25±0.046
Total Protein	27.38±1.046	29.42±1.118	27.20±1.324	28.00±1.119	28.25±1.046	27.29±1.118
Cholesterol	3.69±0.175	3.76±0.175	3.30±0.202	3.37±0.187	3.66±0.175	3.80±0.187
Triglycerides	0.59±0.100	0.39±0.100	0.42±0.114	0.48±0.105	0.52±0.100	0.51±0.106
HDL Cholesterol	2.59 ^{ab} ±0.140	2.78 ^a ±0.140	2.38 ^{ab} ±0.162	2.35 ^b ±0.140	2.48 ^{ab} ±0.140	2.56 ^{ab} ±0.150
LDL Cholesterol	0.83 ^{ab} ±0.093	0.76 ^{ab} ±0.108	0.61 ^a ±0.108	0.78 ^{ab} ±0.100	0.94 ^b ±0.094	1.00 ^b ±0.100
Glucose	13.80±0.863	11.80±0.946	13.56±0.946	11.62±0.946	12.39±0.748	12.35±1.057

^{ab} Means within the same row that do not share a common superscripts are significantly different (P<0.05) from each other.

T₁- *Aloe ferox* whole leaf juice administered throughout the production

T₂- *Aloe ferox* whole leaf juice administered during the first two weeks of the production cycle

T₃- *Aloe ferox* whole leaf juice administered in the third and fourth week of the production cycle

T₄- Terramycin administered at the beginning of the production cycle

T₅- Terramycin administered in the middle of the production cycle

T₆- Distilled water administered throughout the production cycle

cycle resulted in the lowest values (0.61 mmol/L) for LDL cholesterol. Ognik and Merska (2012) reported a 20% increase in HDL cholesterol in hens that were administered with *Aloe spp.* extract.

This showed that *A. ferox* can influence liver production of cholesterol by increasing desirable HDL cholesterol and reducing the undesirable LDL cholesterol. This may be due to inhibition of hepatic-3-hydroxyl-3-methylglutaryl Coenzyme A (HMG-CoA) which synthesizes and regulates cholesterol in the liver (Crowell, 1999; Sharifi *et al.*, 2013).

4.4 Conclusion

Although farmers use *A. ferox* for the purpose of treating and controlling diseases and parasites, this study showed that it can have additional benefits that may not necessarily be evident to farmers. For example, inclusion of *A. ferox* in this study enhanced growth performance by improving FI, ADG, HDL cholesterol and decreasing LDL cholesterol. Inclusion of *A. ferox* throughout the production cycle can result in numerically higher dressing percentage although feed utilization is not as efficient as administering from day 15-21. Similarly, *A. ferox* positively affected the health status of the birds as evident by significantly elevated levels of HDL cholesterol in the blood and a reduction of potentially harmful LDL cholesterol. However, further studies need to be done to determine the effect of different dosages of *A. ferox* in drinking water on growth performance, carcass characteristics and blood biochemistry. There is also need to determine the effect *A. ferox* on the quality of the end product of broiler production, which is meat. Hence the next chapter seeks to determine the effect of *A. ferox* on meat quality and fatty acid composition of broiler meat.

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CHAPTER 5: Effect of *Aloe ferox* on physico-chemical characteristics, fatty acids and oxidative stability of broiler meat

Abstract

The objective of this study was to determine the effect of *Aloe ferox* in drinking water administered at different stages of production on physico-chemical characteristics, fatty acids and oxidative stability of broiler meat. Six hundred birds were randomly allocated among 6 treatments, each with 100 birds. The treatment groups were distributed as follows : 20ml/L of fresh aqueous *Aloe ferox* whole leaf juice (ALJ) was administered in drinking water to T₁, T₂ and T₃, from day one to day 35, day one to day 14 and day 15 to day 28, respectively. T₄ and T₅ (Positive controls) were treated with terramycin at a dosage of 14g/litre of drinking water from day one to day 6 and from day 15 to day 20, respectively. T₆ (negative control) received distilled water from day one to day 35. Two birds from each treatment were slaughtered at day 35 for determination of meat quality. The results showed no significant effects ($P > 0.05$) of treatment on pH, colour, cooking loss and tenderness. Significant treatment effects ($P < 0.05$) were observed on the composition of the PUFA eicosatrienoic acid (C20:3c8, 11, 14(n-6)) where it was significantly lower in the *A. ferox* treatment groups than the positive controls. Thigh meat had significant ($P < 0.05$) treatment effects on composition of palmitoleic acid (C16:1c9) and g-linolenic acid (C18:3c6, 9, 12 (n-3)). This shows that inclusion of *A. ferox* whole leaf juice throughout the production cycle may result in better physico-chemical characteristics of broiler meat. In addition, *A. ferox* may be used to modify fatty acid profiles of breast and thigh muscle.

Keywords: Physico-chemical characteristics, *Aloe ferox*, tenderness, cooking loss, colour, pH

5.1 Introduction

Chicken has contributed significantly to the global market as a cheap source of protein which is culturally and religiously acceptable. Consumers prefer it as a healthier option over red meat because chicken contains low cholesterol, high amounts of mono-unsaturated fats and also high proportions of poly-unsaturated fatty acids particularly, omega 3 fatty acids (Bonoli *et al.*, 2007). As a result, chicken meat has been recommended in reducing the chances of coronary heart disease, cancer and Alzheimer's disease in consumers (Okuyama *et al.*, 1997; Michikawa, 2003; Bingham, 2006). Other factors affecting consumer preference of chicken meat include its tenderness, colour, juiciness, marbling and typical flavour (Chulayo *et al.*, 2011). Although chicken is highly recommended, there are factors such as nutrition and health at different levels of production, which affect its meat quality (Nkukwana *et al.*, 2014).

With the consumer preferences shifting towards organic meat, focus has now been put on replacing synthetic additives and drugs with plant based products. Plants are reported to contain aromatic compounds that influence health status, growth performance and meat quality of broilers (Cross *et al.*, 2007; Nkukwana *et al.*, 2014). Such plants include, *Aloe ferox* (Bitter Aloe; Ikhala), a plant traditionally used for therapeutic, prophylactic and nutritional purposes in the rural areas of Sub-Saharan Africa (van Wyk and Gericke, 2000; Dold and Cocks, 2001). *Aloe ferox* contains vast amounts of bioactive compounds. Among these are minerals particularly iron which play a vital role in treating anaemia (Bassetti and Sala, 2005). The spongy mesophyll of the leaf produces a yellow sap which is rich in saponins, amino acids, enzymes, hormones and organic acids (Magwa *et al.*, 2006). The palisade mesophyll contains anthraquinones particularly aloin which is responsible for the pungent smell and bitter taste of *A.ferox*. It also contains aloeresin, a compound responsible for its antioxidant properties (Jones *et al.*, 2002). Due to

numerous bioactive compounds found in *A. ferox*, its mode of action may involve the action of a single compound or synergetic effect of many compounds (Eloff *et al*, 2008). Hence, it is necessary to investigate its effect on meat quality in broilers.

Meat quality attributes of importance include pH, colour, thawing loss, cooking loss and tenderness. Postmortem ultimate pH (pH_u), is of paramount importance as it affects colour, tenderness and water-holding capacity (Aberle *et al.*, 2001). Correlations of pH, colour and tenderness have been reported (Muchenje *et al.*, 2009). Low pH ($\text{pH}_{45} < 6$ and $\text{pH}_{24} \leq 5.3$) results in Pale, Soft, Exudative (PSE) in poultry whereby the meat is light coloured with a marshy texture and quickly loses water through dripping (van Laack *et al.*, 2000; Swatland *et al.*, 2008). Pale, Soft, Exudative results in high economic losses as consumers' decisions at the point of purchase are partly influenced by meat colour (Viljoena *et al.*, 2002). Furthermore, PSE also reduces oxidative stability of the meat thereby decreasing its shelf life.

Tenderness is an attribute that determines palatability of the meat. Some of the factors that affect tenderness in chicken meat are muscle fibre type and size (Tůmová and Teimouri, 2009). The *pectoralis* muscle in broilers particularly contains only the Type II muscle fibres which have a characteristic large size (Roy *et al.*, 2006). Chen *et al.* (2007) reported that the larger the muscle fibres the tougher the meat and *vice versa*. In addition, the Type II muscle fibres are fast contracting hence influencing rigor mortis and are characterised by rapid glycogenolysis and lactate production in response to stress (Tůmová and Teimouri, 2009). Stress on the other hand encourages release of free radicals which may promotes protein denaturation and reduces tenderness. *A. ferox* have been reported to have phenolic compounds which can reduce lipid and protein oxidation thereby increasing tenderness of the meat.

Other attributes of importance include thawing and cooking loss and these determine the water holding capacity of the meat. They affect the nutritional content of meat that is available for utilisation by the consumer. Water holding capacity is affected by the fatty acid content of the diet as these fatty acids translate into the fatty acid composition in the meat (Moyo, 2011). High cooking and thawing losses are an indication of high loss of nutrients through drip as actin and myosin in the muscle shrinks (Yu *et al.*, 2005; Jama *et al.*, 2008).

Dietary fatty acid levels have an impact on the development of coronary heart diseases and atherosclerosis (Daneshyar *et al.*, 2011). Although broiler meat is known to have low cholesterol and fat content (Ponte *et al.*, 2004), it can easily be manipulated to further reduce its cholesterol and fat levels by inclusion of phytochemical agents. For example, thyme, alfalfa and turmeric have been reported to reduce cholesterol and influence desirable fatty acid profiles in broilers (Ponte *et al.*, 2004; Bolukbasi *et al.*, 2006; Daneshyar *et al.*, 2011).

The wide use of *A. ferox* in drinking water has been reported among rural farmers (Mwale *et al.*, 2005). In addition its efficacy as a medicinal plant in livestock production has been ascertained by Mwale and Masika (2009) and Maphosa *et al.* (2013). However, what is not known is the effect of this practice on chicken meat quality. Therefore, the objective of this study was to determine the effect of *A. ferox* on the physico-chemical characteristics, fatty acid composition and oxidative stability of broiler meat.

5.2 Materials and methodology

5.2.1 Animal, feeding and slaughter management

The study was conducted at Fort Cox Agricultural College farm, Eastern Cape and the description of the study site was given in Section 4.2.2. The description of the housing, diets

was the same as described in Sections 4.2.3 and 4.2.4, respectively. Slaughter management was done as described in Section 4.2.6.

5.2.2 Determination of meat quality

5.2.2.1 Determination of pH

Measurements of pH were made 45 minutes after slaughter (pH₄₅) and 24 hours *post-mortem* (pH₂₄). The measurements were taken from the breast muscle using a portable pH meter (CRISON pH25, CRISON Instruments SA, Spain) which was calibrated using pH 4, 7 and 9 standard solutions before each measurement was taken. The carcasses were transported to the University of Fort Hare, Meat Science Laboratory, where pH₂₄ measurements were taken.

5.2.2.2 Determination of colour

Meat colour (L* = Lightness, a* = Redness and b* = Yellowness) determination was done by use of a Minolta colour-guide 45/0 BYK-Gardener GmbH machine with a 20mm diameter measurement and illuminant D65-day light, 100 standard observer. After calibration, colour was measured on the cranial, medial surface (bone side) in an area free of obvious colour defects (bruises, discolorations, haemorrhages, full blood vessels, picking damage, or any other condition which may have affected a uniform colour reading) (Petracchi *et al.*, 2004).

5.2.2.3 Determination of cooking loss

Chicken breast muscles were weighed and placed in water tight polyethylene bags. The samples were cooked in a water bath at 85°C for 45 minutes until an internal temperature of 70°C was reached. Meat samples were then cooled, blotted dry and weighed. The following formula was used to calculate Cooking loss (CL):

$$\text{CL \%} = [(\text{weight before cooking} - \text{weight after cooking}) \div \text{weight before cooking}] \times 100$$

(Ding *et al.*, 2010).

5.2.2.4 Determination of tenderness

Cooked samples were used for tenderness determination. Three sub-samples with a core thickness of 10mm were sheared perpendicular to the fibre using a Warner Bratzler (WB) shear device mounted on an Instron (Model 3344) Universal testing apparatus (cross head speed at 400 mm/min, one shear in the centre of each core). Thereafter, the mean load (N) was recorded.

5.2.3 Fatty acid profile determination

Total lipid from muscle samples were quantitatively extracted, according to the method of Folch *et al.* (1957), using chloroform and methanol in a ratio of 2:1. An antioxidant, butylated hydroxytoluene was added at a concentration of 0.001 % to the chloroform: methanol mixture. A rotary evaporator was used to dry the fat extracts under vacuum and the extracts were dried overnight in a vacuum oven at 50°C, using phosphorus pentoxide as a moisture adsorbent. Total extractable fat was determined gravimetrically from the extracted fat and expressed as percent fat (w/w) per 100 g tissue. The extracted fat from muscle was stored in a polytop (glass vial, with push-in top) under a blanket of nitrogen and frozen at -20°C pending fatty acid analyses.

A lipid aliquot (20 mg) of muscle lipid was transferred into a Teflon-lined screw-top test tube by means of a disposable glass pasteur pipette. Fatty acids were transesterified to form methyl esters using 0.5 N NaOH in methanol and 14 % boron trifluoride in methanol (Park and Goins, 1994). FAMES from subcutaneous muscle were quantified using a Varian 430 flame ionization GC, with a fused silica capillary column, Chrompack CPSIL 88 (100 m length, 0.25 mm ID, 0.2 µm film thicknesses). Analysis was performed using an initial isothermic period (40°C for 2 minutes). Thereafter, temperature was increased at a rate of 4°C/minute to 230°C. Finally an

isothermic period of 230°C for 10 minutes followed. FAMES n-hexane (1µl) were injected into the column using a Varian CP 8400 Autosampler. The injection port and detector were both maintained at 250°C. Hydrogen, at 45 psi, functioned as the carrier gas, while nitrogen was employed as the makeup gas. Galaxy Chromatography Software recorded the chromatograms.

Fatty acid methyl ester samples were identified by comparing the retention times of FAME peaks from samples with those of standards obtained from Supelco (Supelco 37 Component Fame Mix 47885-U, Sigma-Aldrich Aston Manor, Pretoria, South Africa). All other reagents and solvents were of analytical grade and obtained from Merck Chemicals (Pty Ltd, Halfway House, Johannesburg, South Africa). Fatty acids were expressed as the proportion of each individual fatty acid to the total of all fatty acids present in the sample. The following fatty acid combinations were calculated: omega-3 (n-3) fatty acids, omega-6 (n-6) fatty acids, total saturated fatty acids (SFA), total monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), PUFA/SFA ratio (P/S), n-6/n-3 ratio, atherogenicity index and desaturase index.

5.2.4 Oxidative stability of fresh meat

A 5 g sample of lean meat (removed from the middle of each cut) was used for TBARS analysis using the aqueous acid extraction method of Raharjo *et al.* (1992) to determine lipid oxidation. The following reagents were added to the test tubes: 0.15 M KCL buffer (1.12 g KCL plus 0.002 g BHT in 100 ml of distilled water), 1% (w/v) TBA (2-thiobarbituric acid), 50 mm NaOH mixture (0.2 g NaOH plus 1 g TBA in 100 ml of distilled water), 2.8% (w/v) TCA (Trichloroacetate; 2.8 g in distilled water) and n-Butanol. A standard stock solution of 0.001 M TMP (1, 1, 3, 3-tetramethoxypropane) made up of 0.0164 ml 99% TMP in 100 ml distilled water was used. Test tubes were vortexed, heated in a boiling water bath (100 °C) for 10 minutes, cooled at room temperature, and then centrifuged for 30 minutes at 4°C at 4000 rpm. Absorbance of the

supernatant was measured at 532 nm against a blank reagent using a spectrophotometer. The percentage on lipid oxidation inhibition was calculated by the following equation: [(absorbance of control – absorbance of sample) ÷ absorbance of control × 100]. Thiobarbituric acid-reacting substances (TBARS) were expressed as micrograms of malonaldehyde (MDA) per gram of meat.

5.2.5 Statistical analysis

The PROC GLM of SAS (2003) was used to analyse the effect of the *A.ferox* on pH, L*, a*, b*, cooking loss, WB shear force values. Separation of means was done using Least Significant Difference test of SAS (2003).

The statistical model used was:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where Y_{ij} = pH, L*, a*, b*, CL, WB shear force values, breast muscle fatty acid composition, thigh muscle fatty acid composition, breast muscle TBARS, thigh muscle TBARS;

μ = Overall mean;

T_i = Treatment effect;

e_{ij} = Random error

5.3 Results and Discussion

The effects of inclusion of *A. ferox* in drinking water administered at different stages of production, on physico-chemical characteristics of broiler meat are shown in Table 5.1. There were no significant differences ($P > 0.05$) among groups treated with *A.ferox* and the controls, on pH, colour, cooking loss and tenderness. The results in this study concur with He *et al.* (2010),

Table 5.1: Effect of *Aloe ferox*, terramycin and distilled water on meat pH, colour, tenderness and cooking loss (%)

Meat Attributes	Treatments					
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆
pH						
pH ₄₅	6.3±0.11	6.3±0.09	6.3±0.11	6.4±0.11	6.3±0.11	6.3±0.09
pH ₂₄	6.2±0.11	6.1±0.11	6.2±0.11	6.2±0.11	6.1±0.11	6.0±0.11
Colour						
L [*]	38.5±0.74	38.6±0.74	39.5±0.74	37.8±0.74	37.8±0.74	37.4±0.74
a [*]	4.1±0.47	4.0±0.47	3.7±0.47	4.4±0.47	4.4±0.47	5.0±0.47
b [*]	15.3±0.58	16.2±0.58	16.5±0.58	14.8±0.58	15.4±0.58	15.4±0.58
Shear force						
(N)	13.9±0.82	14.4±0.71	13.7±0.71	13.8±0.71	13.7±0.82	14.3±0.82
Cooking						
Loss (%)	12.6±1.80	16.2±1.56	16.1±1.56	14.7±1.56	15.32±1.80	16.22±1.80

^a Means in the same row with similar superscripts are not significantly different (P>0.05) from each other. L^{*} - lightness, a^{*} - redness, b^{*} - yellowness

T₁- ALJ administered throughout the production

T₂- ALJ administered during the first two weeks of the production cycle

T₃- ALJ administered in the third and fourth week of the production cycle

T₄- Terramycin administered at the beginning of the production cycle

T₅- Terramycin administered in the middle of the production cycle

T₆- Distilled water administered throughout the production cycle

Daneshyar *et al.* (2011) and Moyo *et al.* (2014) who reported no significant effect of plant extracts on pH₄₅ and pH₂₄. These observations also substantiate the claim by communal farmers (Chapter 3) that administering *A.ferox* extracts to chickens does not affect meat quality. The pH at 45 minutes can be an indicator of PSE whereby pH values below 6 can be an indication of PSE (van Laack *et al.*, 2000). However, the results in this study pH₄₅ (6.3-6.4) fell within the normal range. Studies by Loots *et al.* (2007) and Mhaladi *et al.*(2013) have shown that aqueous *A. ferox* contains ascorbic acid, flavonoids and alkaloids which reduce the rate of lipid oxidation and hence increase pH (Anwar *et al.*, 2007). Another research using plants by Wapi *et al.* (2013) revealed significantly higher pH values for broilers treated with *Moringa oleifera* compared to those that received a basal diet only. *M. oleifera* also contains high levels of antioxidants like *A. ferox*.

According to Zhuang *et al.* (2007), standard pH values at 24 hours are between 5.4-5.8. However, generally high pH₂₄ values (6.0-6.2) among all the treatments were recorded in this study. This could have been attributed to the effects of heat stress which was noticed in week 4 when ambient temperatures reached 40°C, resulting in 3.5% mortality. High ambient temperature negatively affects meat quality as heat stressed birds tend to have disturbances in glycolytic metabolism, particularly in the breast muscle (Sandercock *et al.*, 2001; Skomorucha *et al.*, 2010). Heat stress gives rise to reduced levels of glycogen in the muscles. This subsequently limits postmortem lactic acid availability in the muscles, therefore leading to high ultimate pH values (Muchenje *et al.*, 2009; Muchenje and Ndou, 2011).

There were no significant differences (P>0.05) in meat colour among the different treatments. Other studies involving plant extracts were reported by Peña *et al.* (2003) and He *et al.* (2010) who indicated that meat colour was not affected by inclusion of citric flavonoids and α -

tocopherol in broiler diets. However, contrasting results were reported by Wapi *et al.* (2013) who included *Moringa oleifera* leaf extracts in broiler diet. Chicken meat with L* value that is less than 45, as in this case, is regarded as dark (Fletcher *et al.*, 2002). The generally low L* values in all treatments may have been attributed to the high pH₂₄. Lu *et al.* (2007) associated high pH₂₄ with darker meat colour that is lower L* values. Furthermore, in a study by Ngambu *et al.* (2013), *Acacia karoo* supplementation resulted in meat with significantly lower pH and higher L* values compared to the control. On the other hand, other authors have reported animals fed on tanniferous diets to produce meat with a light colour (Priolo and Vasta, 2007). Therefore, significant amounts of tannins in *A. ferox* increase lightness by reducing the synthesis of vitamin B₁₂ – precursor of haeme pigments (Kambizi *et al.*, 2004; Vasta *et al.*, 2008).

Redness (a*) and yellowness (b*) of the broiler breast meat were not significantly affected by supplementation of *A.ferox* in drinking water. These results are in agreement with those by Elmali *et al.*(2014) and Park *et al.* (2014) who reported that lightness, redness and yellowness coordinates were not affected by supplementation of plant extracts in drinking water.

In this study, *A.ferox* had no effect (P>0.05) on the tenderness and cooking loss of broiler breast meat. This contradicts findings by Li *et al.* (2009) which revealed that inclusion of α -tocopherol improved tenderness of broiler meat. Although inclusion of *A. ferox* in this study did not affect tenderness, there are reports which mention that the plant additives improve tenderness encouraging solubility of collagen and myofibrillar proteins which is mostly (Brown *et al.*, 1982). In addition, Chulayo *et al.* (2011) reported that meat from chickens treated with *A. ferox* in drinking water has low amounts of connective tissue which was confirmed during sensory evaluation.

Cooking loss determines the amount of nutrients that are lost after cooking. In this study, there were no significant treatment effects ($P>0.05$) on cooking loss. These findings concur with Comale *et al.* (2011) who reported that phytotherapeutic compounds do not affect meat cooking loss. Lower cooking loss is linked to higher pH (Mushi *et al.* 2009). This is because high net charge created by high pH increases the space within myofibrillar proteins thereby encouraging water binding and retention within the muscle (Bruce *et al.*, 2003; Mushi *et al.*, 2009).

Effect of inclusion of *A. ferox* in drinking water on fatty acid content of broiler breast and thigh meat are presented in Tables 5.2 and 5.3. The results of this study show that *A. ferox* inclusion did not have significant effect ($P>0.05$) on saturated fatty acids (SFAs) and mono unsaturated fatty acids (MUFAs) of the breast meat. However, significant treatment effect ($P<0.05$) was noted on the composition of the PUFA eicosatrienoic acid (C20:3c8, 11, 14(n-6)) where it was significantly lower in the *A. ferox* treatment groups than the positive controls. PUFAs are essential in reducing the risk of cardio-vascular and inflammatory diseases (Simopoulos, 2006). In contrast, prior studies by Loots *et al.* (2007) and Dangarembizi *et al.* (2013) revealed that *A. ferox* contains PUFAs which may suggest that PUFA content in the breast muscle of *A. ferox* treatments should be higher than the controls.

The thigh meat had significant ($P<0.05$) treatment effects on composition of palmitoleic acid (C16:1c9) and g-linolenic acid (C18:3c6, 9, 12 (n-3)). *Aloe ferox* significantly influenced accumulation of palmitoleic acid in the thigh muscle than terramycin inclusion in the third week. This may be because palmitoleic acid is one of the MUFAs found in *A. ferox* (Loot *et al.*, 2007). Palmitoleic acid is important in both the animal subjects and meat consumers as it influences improvement in the circulating lipid profiles (Griel *et al.*, 2008). This study also revealed that the meat from birds that received *A. ferox* throughout the production cycle (T_1) had significantly

higher levels of g-linolenic acid in the thigh muscle than the negative control (T₆). This may be attributed to *Aloe ferox* containing vast amounts of linoleic acid (C18:2c9, 12 (n-6)) (Loot *et al.*, 2007; Dangarembizi *et al.*, 2013). Linoleic acid in *A. ferox* is synthesized to g-linolenic acid (omega-6- fatty acid) after assimilation by means of the enzyme delta-6-desaturase (Fan and Chapkin, 1998). Hence, g-linolenic acid can be incorporated in the muscle fatty acid profile as a product of linoleic acid synthesis. Unlike linoleic acid, g-linolenic acid has an anti-inflammatory function in the body (Miles *et al.*, 2004).

The current study also revealed that breast meat had numerically higher PUFA content than thigh meat. This is in line with the findings of Shahbazi *et al.*, (2014) and attributed the difference to the different functions played by fatty acids together with the proportion of phospholipids in the tissues. Breast muscles have high phospholipid content which positively correlates to high PUFA proportion since these two bio-compounds work together.

The effects of *Aloe ferox* inclusion in drinking water on Thiobarbituric acid-reacting substances (TBARS) are presented in Table 5.4. Although antioxidant polyphenols, indoles and alkaloids in *A. ferox* have been identified, this study showed no significant ($P>0.05$) effect of *A. ferox* on TBARS of both breast and thigh meat. Examples of polyphenols isolated include aloe emodin, ferulic acid, *p*-coumaric, benzoic acid and vanillic acid (Loot *et al.*, 2007). The contribution of these polyphenols in this study was minimal because their antioxidant capacity is dependent on several factors which include concentration, bioavailability and mechanism of action (Loot *et al.*, 2007).

5.4 Conclusion

In conclusion, the inclusion of *A. ferox* in drinking water produced meat that is comparable with that treated with antibiotics. In addition, treating chickens with *A. ferox* at any stage of production does not adversely affect their meat quality. This shows that *A. ferox* in addition to ensuring good health of chickens, it can be used to modify aspects of meat quality particularly composition of palmitoleic acid and g-linolenic acid in the thigh. However, further investigations should be done to determine whether different dosages of ALJ in drinking water can influence quality, fatty acid composition and oxidative stability of broiler meat. It is also necessary to conduct future on-farm investigations in controlled environments since in this study temperature affected the organoleptic characteristics particularly pH.

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CHAPTER 6: General Discussion, Conclusions and Recommendations

6.1 General discussion

The current study was conducted to determine the socio-economic factors that affect use of *Aloe ferox* in rural areas and the extent of use, its effect on broiler feed intake, feed conversion ratio, average daily gain, body weight, blood biochemistry, physico-chemical characteristics of broiler meat, fatty acid composition and oxidative stability of the meat. A questionnaire survey in this study revealed that the wide use of *A. ferox* in Mt Frere was influenced by the low literacy level and income in these villages. However a review of literature revealed that other determinants influencing the use of medicinal plants in chicken production include the claim of efficacy by rural farmers against chicken ailments (Mwale and Masika, 2009), accessibility and affordability of medicinal plants (Guèye, 2002) and gender of head of the household (Mwale *et al.*, 2005). The study also revealed that *A. ferox* is a popular medicinal plant used for treatment of chicken diseases and control of parasites in Eastern Cape.

An on farm trial to determine the effect of *A. ferox* on growth performance revealed that it has a potential to positively affect growth performance and carcass characteristics of broilers. However, administering *A. ferox* in drinking water throughout the production cycle resulted in higher FCR. Since feed is the most expensive input in a broiler enterprise, the continuous use of *A. ferox* will reduce feed utilization and hence this reduces profitability because the feed requirements needed also increase. Other researchers also found *Aloe spp.* administered in drinking water to influence growth performance (Bejar and Colapo, 2005; Olupona *et al.*, 2009). No significant effect of *A. ferox* was found on dressing percentage and organ weights and this shows that the medicinal use of *A. ferox* in chickens has no adverse effect on the carcass quality.

Blood biochemistry revealed that inclusion of *A. ferox* influenced the production of desirable HDL while the undesirable LDL is reduced. Contrary results were found by Mehala and Moorthy (2008) where *A. vera* had no influence on HDL cholesterol and LDL cholesterol.

The effect of *A. ferox* inclusion on meat quality of broilers showed results that were comparable with that of terramycin. The claims of farmers in Chapter 3 that the use of *A. ferox* does not change the chicken meat quality were supported by the findings of this study. Meat tenderness, cooking loss, pH, and colour did not differ across all treatments and this may have been influenced by the isocaloric and isonitrogenous commercial diet fed to the birds. *Aloe ferox* improved composition of palmitoleic acid (C16:1c9) and g-linolenic acid (C18:3c6, 9, 12 (n-3)) of thigh meat and reduced the composition of eicosatrienoic acid in the breast muscle. The reason for the reduction in the composition of eicosatrienoic acid is not clear. However, the elevated composition of g-linolenic acid in the thigh muscle may be because of the supply of linoleic acid in the *A. ferox* which is then converted to g-linolenic acid in the muscle.

6.2 Conclusions

Socio-economic determinants that affected the use of *A. ferox* to treat chicken health ailments in communal areas were level of education and income. This can be attributed to *A. ferox* being affordable and locally available. In addition, *A. ferox* was administered to both indigenous and broiler chickens by communal farmers. The use of *A. ferox* for medicinal purposes did not have detrimental effects on growth performance, carcass quality, meat quality, fatty acid composition and meat oxidative stability of broilers. In addition, its inclusion at different stages of production did not negatively affect growth parameters, blood parameters, meat quality, fatty acid profiles and oxidative stability. Although *A. ferox* inclusion throughout the production cycle resulted in

low levels of eicosatrienoic acid (C20:3c8, 11, 14(n-6)), the reason for this is not clear and warrants further investigations.

6.3 Recommendations

- *Aloe ferox* may be given to broilers at any stage of production in order to influence growth performance, blood biochemistry, meat quality, fatty acid profiles and oxidative stability of the meat.

Areas that require further research include:

- The effect of different dosages of *A. ferox* in drinking water on growth performance, blood biochemistry, physico-chemical properties and fatty acid profiling broiler meat.
- Effect of *A. ferox* inclusion on shelf life of breast and thigh meat.

6.4 References

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APPENDICES

Appendix 1: Questionnaire

Extent of utilization of medicinal plants in the treatment and control of chicken diseases and parasites in Mt Frere, Eastern Cape

This questionnaire is to generate information on the various plants used by farmers in the rural areas of Eastern Cape. Information generated through this questionnaire will be used only for the purposes of this research there are no right or wrong answers.

Questionnaire number

Date

Year **Month** **Day**

Province _____

Enumerator name _____

District _____

Respondents name _____

Ward _____

Sex of respondent _____

Village _____

SECTION A: HOUSEHOLD DEMOGRAPHY

1. Who is the head of the household? 1) Father 2) Mother 3) Children 4) other*
*Specify _____

2. Table on household demographics

Household member	Relation with household head ^a	Marital status ^b	Gender	Age ^c	Highest level of education ^d	Animal husbandry training ^e	Occupation ^f

^a: (1)- Father (2) mother, (3) son (4) daughter (5) daughter in law (6) son in law (7) specify

^b: (1) single, (2) married, (3) divorced, (4) widowed, (5) separated, (6) other (Specify)

^c: (1) ≤ 25 years, (2) 26 – 40 years, (3) 41 – 55 years, (4) 56 – 70 years, (5) > 70

^d: (1) never attended school, (2) Primary level, (3) Secondary, (4) Tertiary level

^e: (1) Master farmer training, (2) Certificate in Agriculture/Veterinary, (3) Degree Agriculture/Veterinary, (4) None

^f: (1) teacher, (2) student (3) church leader (4) traditional healer (5) nurse (6) police (7) Extension officer (8) other (specify)

3. Sources of income? (1) Crops, (2) livestock, (3) salaries/wages

(4) Other (specify) _____

SECTION B: INVENTORY

4. What functions do chickens play in your household? Complete table below

Role	Rank according to importance from 1 to 4 which will be the least important	Rank sub functions according to importance within major role 1= high, 2= medium, 3= low, 4= not important			
Consumption		Meat and eggs for the household	Meat for sale	Live chickens for sale	Eggs for sale
Social		Installation of ancestral spirits	Bride wealth	Social status (pleasure in ownership)	Gifts e.g weddings
Other (specify)					

5. Fill in below the number of chickens owned

Number	<input type="text"/>
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6. Who owns the chickens (1) Father (2) Mother (3) Children 4) Other (specify)

7. Breed composition

a) Indigenous breed

b) Broilers

8. Who treats sick chickens? (1) Veterinary assistant (2) Agricultural extension worker (3) Father (4) Mother (5) Other (Specify)

SECTIONC: CHICKEN DISEASE SITUATION

9. Do you have problems with chicken diseases and parasites? (1) Yes (2) No

10. Of the conditions that affect chickens fill in the following table and rank them according to the following ranks; (1) most prevalent, (2) moderately prevalent (3) rare

Condition	Frequency	Deaths resulting from condition	Deaths affects which age group
Newcastle: Sneezing, greenish watery diarrhea, muscle tremors, sudden death			
Influenza: ruffled feathers, swelling of the head, bloody discharge from nostrils			

Coccidiosis: Weak, pale comb and skin, loss of appetite ,blood and yellowish foamy poop			
External parasites: Mites (Intwala), Lice (Amangolwane) , Fleas (Icukuthu)			
Internal parasites: (Intshulube)			

SECTION D: CHICKEN DISEASE AND PARASITE CONTROL

11. Do you treat any diseases or conditions affecting your chickens? (1) Yes (2)No

12. What type of medicine do you use to cure chicken diseases and parasites?

Traditional medicine Commercial drugs

13. How much does it cost to acquire the medicine?

14. How do you rate the effectiveness of the treatment methods? Use keys below.

Traditional medicine Commercial drugs

(1) Very effective (2) moderately effective (3) not effective (4) do not know

15. Which plant based medicines do you use for promoting growth and control of diseases and parasites in your chickens.

Name of plant	Use	Parts of the plant used	Quantity used	How applied	Preparation method	Rank according to use frequency

*(1) most frequent (2) moderately used (3) rarely used (4) never

16. If for promoting growth and control of chicken diseases and parasites you use plant based medicine, how did you obtain the knowledge? The most important source.

- (1) Oral tradition from family member (specify) (2) other farmers
 (3) Read somewhere (4) Local elders

17. Are traditional medicines more effective than conventional medicine?

Yes No

18. Explain reason for response in 17 above.

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19. Are there any side effects in chicken or humans of the remedies used? If any, describe them.

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20. Are there any withdrawal periods from time of administration to time of eating eggs or meat?

.....

21. If so what is the aim of doing this?

.....

22. Do any of the remedies cause change in color or taste of meat or eggs?

.....

THANK YOU FOR PARTICIPATING IN THIS STUDY.

Table 5.2: Effect of *Aloe ferox* inclusion in drinking water on fatty acid composition of broiler breast meat

Fatty acid (% of total fatty acids)	Treatment					
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆
Lauric	0.257±0.045	0.253±0.045	0.248±0.039	0.225±0.039	0.233±0.045	0.210±0.039
Myristic	0.597±0.047	0.583±0.047	0.595±0.040	0.558±0.040	0.577±0.047	0.575±0.040
Palmitic	25.580±0.582	26.090±0.582	26.045±0.504	25.620±0.504	24.960±0.582	25.805±0.504
Stearic acid	8.043±0.714	8.193±0.714	8.430±0.619	8.293±0.619	8.553±0.714	8.770±0.619
Total SFA	34.563±0.610	35.153±0.610	35.378±0.528	34.718±0.528	34.397±0.610	35.453±0.528
Palmitoleic	6.097±0.704	6.057±0.704	5.978±0.610	5.983±0.610	5.063±0.704	5.570±0.610
Heptadecenoic	0.450±0.122	0.340±0.122	0.400±0.099	0.503±0.086	0.630±0.122	0.450±0.86
Oleic	33.823±1.326	33.860±1.326	32.335±1.148	32.693±1.148	34.333±1.326	32.373±1.148
Vaccenic	3.570±0.201	3.450±0.201	3.685±0.174	3.670±0.174	3.643±0.201	3.607±0.174
Total MUFA	44.170±1.526	43.960±1.526	42.660±1.321	43.163±1.321	44.203±1.525	42.052±1.321
Linoleic	15.673±0.344	15.783±0.34	15.698±0.298	15.780±0.298	15.353±0.343	15.500±0.298
g-Linolenic	0.100±0.172	0.103±0.172	0.103±0.149	0.115±0.149	0.117±0.172	0.120±0.149
Eicosatrienoic	0.055 ^a ±0.008	0.055 ^a ±0.008	0.040 ^a ±0.008	0.090 ^b ±0.010	0.065 ^{ab} ±0.008	0.065 ^{ab} ±0.008
Arachidonic	0.740±0.188	0.973±0.188	1.013±0.163	0.900±0.163	0.883±0.188	0.930±0.163
Total PUFA	0.617±0.040	0.593±0.040	0.623±0.345	0.638±0.035	0.633±0.040	0.625±0.035
Total n-3	1.267±0.169	1.047±0.169	1.263±0.147	1.200±0.147	1.317±0.169	1.325±0.147
Total n-6	20.000±1.177	19.657±1.177	21.140±1.019	19.838±1.019	21.320±1.177	21.030±1.019
PUFA:SFA	0.617±0.040	0.593±0.040	0.623±0.035	0.633±0.035	0.633±0.040	0.625±0.035
n-6/n-3	16.777±1.559	19.047±1.559	16.435±1.350	17.578±1.350	16.783±1.559	16.070±1.350

^a Means in the same row with different superscripts are significantly different (P<0.05) from each other. T₁- ALJ administered throughout the production, T₂- ALJ administered during the first two weeks of the production cycle, T₃- ALJ administered in the third and fourth week of the production cycle, T₄- Terramycin administered at the beginning of the production cycle, T₅- Terramycin administered in the middle of the production cycle, T₆- Distilled water administered throughout the production cycle

Table 5.3: Effect of *A. ferox* inclusion in drinking water on fatty acid composition of broiler thigh meat

Fatty acid (% of total fatty acids)	Treatment					
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆
Lauric	0.433±0.036	0.405±0.031	0.453±0.031	0.373±0.420	0.420±0.035	0.385±0.031
Myristic	0.720±0.026	0.708±0.022	0.732±0.022	0.667±0.026	0.710±0.026	0.705±0.022
Palmitic	25.537±0.610	26.085±0.529	25.933±0.529	24.687±0.610	25.530±0.610	25.598±0.529
Stearic acid	5.603±0.443	5.870±0.383	5.508±0.384	6.220±0.443	5.863±0.443	6.498±0.384
Total SFA	32.353±0.754	33.027±0.754	32.665±0.653	32.103±0.653	32.590±0.754	33.250±0.653
Palmitoleic	7.847 ^{ab} ±0.345	8.320 ^a ±0.300	8.083 ^a ±0.300	8.203 ^a ±0.346	6.953 ^b ±0.346	7.430 ^{ab} ±0.300
Heptadecenoic	0.000±0.053	0.030±0.047	0.025±0.047	0.110±0.054	0.047±0.054	0.123±0.047
Oleic	37.960±1.316	36.585±1.140	37.520±1.140	36.657±1.316	38.847±1.316	36.585±1.140
Vaccenic	3.210±0.16	3.090±0.145	3.178±0.145	3.323±0.168	3.233±0.168	3.308±0.145
Total MUFA	49.437±1.296	48.197±1.296	49.208±1.122	48.825±1.122	48.767±1.296	48.365±1.122
Linoleic	16.123±0.488	15.875±0.423	15.990±0.423	15.927±0.488	15.787±0.488	15.840±0.423
g-Linolenic	0.133 ^a ±0.10	0.125 ^{ab} ±0.009	0.118 ^{ab} ±0.009	0.117 ^{ab} ±0.010	0.110 ^{ab} ±0.010	0.100 ^b ±0.009
Eicosatrienoic	0.217±0.104	0.268±0.090	0.230±0.090	0.393±0.104	0.230±0.104	0.395±0.090
Arachidonic	0.933±0.489	1.443±0.424	1.005±0.424	2.033±0.489	1.017±0.489	1.648±0.424
Total PUFA	0.577±0.032	0.570±0.032	0.560±0.028	0.595±0.028	0.550±0.032	0.568±0.028
Total n-3	0.877±0.107	0.900±0.107	0.852±0.093	0.875±0.093	0.860±0.107	0.910±0.093
Total n-6	17.343±0.842	18.950±0.842	17.713±0.729	17.913±0.729	16.890±0.842	17.198±0.729
PUFA:SFA	0.567±0.032	0.570±0.032	0.560±0.028	0.595±0.028	0.550±0.032	0.568±0.028
n-6/n-3	19.920±1.365	20.340±1.365	20.350±1.182	20.938±1.182	20.043±1.365	20.810±1.182

^a Means in the same row with different superscripts are significantly different (P<0.05) from each other. T₁- ALJ administered throughout the production, T₂- ALJ administered during the first two weeks of the production cycle, T₃- ALJ administered in the third and fourth week of the production cycle, T₄- Terramycin administered at the beginning of the production cycle, T₅- Terramycin administered in the middle of the production cycle, T₆- Distilled water administered throughout the production cycle

Table 5.4: Effect of *Aloe ferox* inclusion in drinking water on TBARS of broiler breast and thigh meat

Treatment	Breast muscle	Thigh muscle
T ₁	0.107±0.040	0.140±0.026
T ₂	0.159±0.040	0.103±0.026
T ₃	0.110±0.035	0.190±0.022
T ₄	0.123±0.035	0.085±0.022
T ₅	0.071±0.040	0.118±0.026
T ₆	0.105±0.035	0.115±0.022

^a Means in the same column with different superscripts are significantly different (P<0.05) from each other.

T₁- ALJ administered throughout the production

T₂- ALJ administered during the first two weeks of the production cycle

T₃- ALJ administered in the third and fourth week of the production cycle

T₄- Terramycin administered at the beginning of the production cycle

T₅- Terramycin administered in the middle of the production cycle

T₆- Distilled water administered throughout the production cycle

