Influence of age and sex on carcass and meat quality traits of scavenging guinea fowls

By

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Declaration

I, **Mabel Tafadzwa Musundire**, pledge that this dissertation has not been submitted to any other University other than the University of KwaZulu-Natal and that it is my original work conducted under the supervision of Professor Michael Chimonyo. All assistance towards the production of this work and all the references contained herein have been duly accredited.

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Mabel Tafadzwa Musundire **Date**

Approved as to style and content by:

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Professor Michael Chimonyo

List of abbreviations

a*	Colour ordinate: Redness value
Ad lib	*Ad libitum*
AOAC	Association of Official Agricultural Chemists
b*	Colour ordinate: Yellowness value of meat
CAB International	Centre for Agriculture and Biosciences International
CP	Crude protein
DM	Dry matter
EE	Ether extract
GF	Guinea fowl
L*	Colour ordinate: Lightness (brightness) value of meat
N	Newtons
Ri	Rank index
SAS	Statistical Analysis Systems
SD	Standard deviation
WHC	Water holding capacity

Abstract

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The purpose of the study was to determine the effect of age and sex on carcass and meat quality characteristics of scavenging guinea fowls in communal production systems. A total of 151 smallholder farmers in Wedza district of Zimbabwe participated in a survey to identify management practices and possible opportunities and constraints in guinea fowl production. Guinea fowls are a tool of alleviating poverty as a potential source of food and income for women who dominated ownership (53.4 %). The majority of the household heads were aged below 55 years. Crops were the main source of income to 46.8 % households whilst 9.8 % households depended on livestock as a source of income. The average guinea fowl flock size per household was 11.36 (SD = 15.44). Guinea fowls were kept mainly for households consumption (ri = 0.44) and income generation (ri = 0.35). Eggs were considered as the main food source followed by meat. About 66.4 % of households did not practice breeding, with the traits selected for included body frame (ri = 0.39), body weight (ri = 0.12) and mothering ability (r = 0.11). The majority of farmers (97.3 %) supplemented feed using locally available feed resources and provided water for their flocks. Keets struggled most from water shortages (ri = 0.45). Predation by birds of prey (ri = 0.31), diseases (ri = 0.22) and wild animal attacks (ri = 0.19) were the main causes of mortality. Ethnoveterinary medicines such as Aloe species and *Capsicum frutescens* were mostly used to treat diseases. The main constraints which reduced production were lack of capital and feed, and predation. Carcass characteristics, internal

organ weights and physicochemical properties of breast meat from 48 scavenging guinea fowls were determined. Guinea fowls comprised of 25 females and 23 males made up of 21 growers (4 – 8 months old) and 27 adults (one year old). In addition, the carcass characteristics, internal organ weights and physicochemical properties of 48 scavenging chickens were used as a benchmark with no statistical comparison with guinea fowls. Chickens comprised of 18 females and 30 males with 19 growers (4 – 8 months old) and 29 adults (one year old). Adult guinea fowls had higher ($P< 0.05$) cold dressed weight than growers (673.1 ± 11.40 and 630.5 ± 12.34 g/kg BW, respectively). Dressing percentage was higher ($P < 0.05$) in adult (69.3 ± 0.92 %) than grower (64.7 ± 1.00 g) birds. There was no influence ($P > 0.05$) of sex on carcass weight. Growing guinea fowls had significantly heavier ($P < 0.05$) relative weights of leg, thigh and drumstick as compared to adults. Breast weight in males was heavier ($P < 0.05$) than in females (198.7 ± 5.37 g and 178.8 ± 6.25 g, respectively). Relative abdominal fat weight was higher ($P < 0.05$) in adults than in growers (24.5 ± 0.57 versus 20.7 ± 0.62 g/kg BW, respectively). Females had significantly higher abdominal fat weight than males. The back weight in adults of 148.7 ± 6.02 g was higher ($P < 0.05$) than 120.6 ± 6.52 g in growers. Sex had no significant effect ($P < 0.05$) on carcass remainders. Growers had heavier ($P < 0.05$) kidney, heart, lung and gizzard weights than adults. Total intestine length in growers (113.2 ± 4.15 cm/kg BW) was longer ($P < 0.05$) than in adults (74.3 ± 3.90 cm/kg BW). Similarly, growing birds had longer ($P < 0.05$) large intestines than mature birds. No sex differences ($P > 0.05$) were observed for intestinal lengths. Dry matter content decreased ($P < 0.05$) with age from 28.7 ± 0.81 % in growing birds to 24.7 ± 0.75 % in adult birds. Ether extract and ash were higher ($P < 0.05$) in adult than grower birds. Females had

more ($P < 0.05$) fat content than males. Age and sex had no effect ($P > 0.05$) on crude protein. Meat from adult birds was darker, redder and yellower ($P < 0.05$) than from growing birds. Breast muscles from females ($b^* = 9.0 \pm 0.32$) were yellower ($P < 0.05$) than from males ($b^* = 7.9 \pm 0.28$). Shear force was higher ($P < 0.05$) in adults than growers. Cooking loss of 21.2 ± 0.42 % in growers was higher ($P < 0.05$) than 16.4 ± 0.39 % in adults. It was concluded that meat yield, carcass traits and meat quality vary with age and sex of guinea fowls.

Key words: guinea fowls, scavenging, production system, management practice, carcass traits, internal organs, *pectoralis major* muscle, carcass, meat quality, age, sex

Publications

1. Effect of age and sex on carcass characteristics and internal organ weights of scavenging chickens and helmeted guinea fowls. Journal of Applied Animal Research (Accepted for publication, Appendix 2).
2. Physicochemical properties of meat from scavenging chickens and helmeted guinea fowls in response to age and sex. British Poultry Science. DOI: 10.1080/00071668.2017.1313961.

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Dedication

To

Lennin Musundire

and My Sunshine:

Tanaya, Tanisha and Tanvi

You are my blessings from above.

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Chapter 1: General Introduction

1.1 Background

Village poultry contributes to poverty alleviation and household food security in the developing world, especially in communal production systems (Alders and Pym, 2009). The majority of farmers in resource-poor communities across Southern Africa practise poultry production (Tekere and Chomunyeke, 2001). In most developing countries, poultry production is based mainly on the scavenging system which has been a traditional component of small farms across the developing world for centuries and is thought to continue as such in the future (Pedersen, 2002). Village poultry in Zimbabwe includes chickens, guinea fowls, turkeys, ducks and pigeons (Kusina and Kusina, 1999). Helmeted guinea fowls (*Numida meleagris*) are a native to Africa (Embury, 2001) where they exist in large numbers in the wild (Mareko *et al*., 2006) and rearing them is a potential alternate to the poultry system (Moreki, 2009). They were first domesticated by ancient Egyptians and spread throughout the world but despite their abundance in most African countries, production is in its infancy (Smith, 2000).

Smallholder farmers are adopting guinea fowl production under free ranging conditions requiring low management requirements (Saina, 2005). The excellent foraging capabilities of guinea fowls makes them a promising genetic resource for evolving a low input-grain saving poultry alternative for production in the developing world (Moreki, 2009). They are hardy birds and are suitable to any agro-climatic conditions. Like village chickens, guinea fowls contribute to annual egg and meat production which are important sources of protein nutrition for poor communities (Poulsen, 2000). Guinea fowl meat has been reported to be acceptable by the majority in all communities making its adoption in poultry production systems easy. Minimal provision of feed, water, health management and housing facilities in the rural communities is well defined and contributes to low productivity of guinea fowls.

Guinea fowls exist in synergy with chickens in rural households. Farmer production objectives and practices vary across seasons due to differences in weather conditions. There are, therefore, unstable types, quality and quantity of scavenging feeding resources available for scavenging poultry species in communal production systems. Guinea fowls are known to utilise a wide variety of flora and fauna (Saina, 2005) whose proportions need to be documented with household leftovers also constituting their diet since domestication. Before identifying preferred feeds by guinea fowls, there is a need to gather knowledge on the flock dynamics, production systems, management practices and constraints the rural poultry producers face.

1.2 Justification

The poultry production system practised by resource-poor farmers include chickens and guinea fowls. Extension research has been carried out on village poultry with great focus on chickens and less on guinea fowls. Information on the various production systems, flock dynamics and constraints faced by the rural guinea fowl producers needs to be gathered. The information would help keep extension service providers up to date with the situation on the ground and, hence, relay correct information to government policy makers and donors who could assist in enhancing rural poultry productivity. These efforts contribute to improved livelihoods of the rural poultry producers.

Guinea fowls are an emerging species in need of research. They are kept together with chickens and their interaction is synergic and antagonistic. The synergic interaction is whereby both species complement each other as they provide similar uses in resource-poor households. They also compete for various resources with other poultry in the same space. This poses the need to investigate how the smallholder farmers benefit from keeping guinea fowls with reference to the popular chickens without statistically comparing the two species. The guinea fowls and their eggs are used in research, particularly in physiology (Ikani and Dafwang, 2004). Aspects of feed resources, growth performance, carcass characteristics, meat quality and issues of food security need to be investigated.

Guinea fowls provide protein for smallholder farmers (Saina *et al.*, 2005; Mapiye *et al.*, 2008). CAB International (1987) stated that guinea fowl meat has 240 and 40 g/kg protein and fat contents, respectively. The protein level makes it ideal for improving the rural community's poor diet and the low fat content makes it ideal for health conscious developed countries. Meat quality of the guinea fowl reared in a free range production system becomes of importance in determining how much it contributes to human nutrition. More research would popularise the birds in the smallholder and commercial sector through dissemination of information on the advantages of guinea fowl species as compared to other village poultry species.

1.3 Objectives

The broad objective of the study was to determine the effect of age and sex on carcass and meat quality characteristics of scavenging guinea fowls. The specific objectives of the study were to:

1. Identify management practices, flock dynamics and possible opportunities and constraints in keeping guinea fowls;
2. Determine the effect of age and sex on carcass characteristics and internal organs in scavenging guinea fowls; and
3. Determine the effect of age and sex on the physical and chemical composition of scavenging guinea fowl meat.

1.4 Hypotheses

The aim of the study was achieved through the following alternate hypotheses which were tested:

1. There is variation in guinea fowl production systems, flock dynamics and opportunities and constraints faced among households.
2. The carcass and internal organ weights vary with age and sex of scavenging guinea fowls.
3. The physicochemical properties of meat from scavenging guinea fowls vary with age and sex.

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Chapter 2: Literature review

2.1 Introduction

The majority of households in the communal lands own village poultry, in particular village chickens and guinea fowls. They are an important source of income and protein in both developed and developing countries. The latter benefits enormously as the majority of the households are generally rural and agrarian (Fasina *et al.*, 2007). Family poultry, such as chickens and guinea fowls play an important role in the rural economy (Kondombo *et al*., 2003). These farmers practise mixed crop-livestock farming system (McAinsh, 2004). Smallholder farmers in Southern Africa are adopting guinea fowl production under free ranging conditions requiring low management (Saina, 2005). Guinea fowls scavenge on a wide variety of feed material including weeds, grasses, insects and waste grains (Adeyemo and Oyejola, 2004). Their excellent scavenging attribute makes them suitable for the low input/low output practice by village poultry producers which, however, exposes the flocks to diseases and low productivity even though they contribute between 30 and 100 % of animal protein consumed by these farmers (Permin *et al*., 2001).

The overall goal of this review is to describe the role of village poultry, mainly focusing on the guinea fowls in Zimbabwe and other developing countries in improving livelihoods, available farm feed resources, production systems and opportunities and constraints faced by farmers in rearing these birds. Various matters related to the carcass characteristics and meat quality is also deliberated since there is scant information on this subject.

2.2 Indigenous guinea fowl types

Guinea fowls are widespread in Africa and classified into different guinea species unlike in chickens where there are various chicken breeds. They are from the Numididae family of birds in the Galliformes order which are alternatively placed in the pheasant family Phasinadea. The helmeted guinea fowl (*Numida melagris*) is one of the most popular breed, native to Africa and some parts of Asia and France, which is docile hence easily tamed. In Zimbabwe the indigenous breed is the blue wattled guinea fowl (*Numidia ptilorhycha*) found in the wild (Saina, 2005). Helmeted guinea fowls' body plumage is black or grey with white dots, red wattled and a blue head.

Its colour varieties include pearl, white, pied, pied splashed and lavender. The most commonly found is the pearl with a purplish colour (Moreki, 2009). It is the popular domesticated breed found in the rural households of most Southern African countries as it can lay eggs under the scavenging low input conditions (Binali and Kanengoni, 1998). Its natural habitat is grassland and scrubland in Africa, south of the Sahara. This bird's noticeable feature is a large backward-curving bony "helmet" on top of its head.

There are several other guinea fowls found across Africa. The white breasted guinea fowl (*Agelastes meleagrides*) is native to various Western African countries including Upper Guinea, Sierra Leone, Ghana, Ivory Coast and Liberia (Allport, 1991). It is characterised by black with a red head, a long black tail and white chest. This is one of the 15 bird species which are endemic to the Upper Guinea Forest (Bird Life International, 2007). The breed which is native to Central African humid forest landscapes is the black guinea fowl (*Agelastes niger*), which is black bodied with a bare neck and head. Plumed guinea fowls (*Guttera plumifera*) are found throughout Central Africa and are closely related to the crested guinea fowl breed. Crested guinea fowl (*Guttera pucherani*) is common in sub-Saharan Africa with a crest on top of its head and dark and dotted feathers. Vulturine guinea fowl (*Acryllium vulturinum*) is the largest of the guinea fowls and native to grasslands of eastern Africa. It has red eyes and a blue, bare head and grows blue and white stripped feathers, which are impressive.

Guinea fowls are seasonal breeders which start laying eggs from 26 to 34 weeks (Ayorinde, 1991; Nwagu, 1997; Oke *et al*., 2004). The laying period in the Southern Hemisphere is during the rainy season with reports in Zimbabwe giving an average of 5 months from October to March (Saina *et al*., 2005). The average number of eggs laid per reproductive hen per season varies with the environment with an average of 42 eggs reported in Zimbabwe (Saina *et al*., 2005), 100 eggs in Ghana (Konlan *et al*., 2011) and 60 to 90 eggs in Nigeria (Ayorinde, 1991) and Botswana (Moreki and Seabo, 2012). The eggs can be hatched using natural (guinea fowls or chicken hens) or artificial incubators. The incubation period lies within 26 to 28 days after incubation (Smith, 2000; Embury, 2001). Hatchability is usually low when using natural incubation (Moreki, 2009) reaching as low as 32 % (Saina *et al*., 2005).

2.3 Role of guinea fowls in resource-limited communities

Indigenous fowls which include chickens, guinea fowls, turkeys and ducks, which are generally kept on a free range system, currently make up more than 80 % of the African continent's poultry flock (Guèye, 1998). Poultry are kept by rural farmers mainly for the egg production for hatching, sale, home consumption, and replacement (Tadelle and Ogle, 2001). These uses have been mainly inclined to be played by the more researched on indigenous chickens.

Guinea fowls production is gaining popularity in resource-limited communities (Kalla *et al*., 2008) where they are raised in an almost mutual relationship with human societies (Kashindye, 2000). Guinea fowls are generally kept in small numbers as a protein source for the smallholder household members (Adjetey, 2006). They grow, reproduce and yield well in both cool and hot conditions similar to indigenous chickens. The birds are relatively disease free; require little water and most useful all year. Guinea fowls have numerous advantages over chickens including low production cost, premium quality meat, and greater capacity to scavenge for insects and grains (Saina *et al*., 2005). They are resistant to common poultry diseases which are worrisome to chicken farmers and scientists, such as Newcastle disease and fowl pox (Microlivestock, 1991; Ikani and Dafwang, 2004). Resource-limited communal farmers find them well suited to the low input/ low output practice in poultry production. Although requiring minimal resource input and considered secondary to other agricultural activities by farmers. Guinea fowl production has an important role in supplying local populations with additional income and high quality protein.

As part of village poultry, guinea fowls also contribute to resource-limited farmers, especially women with high quality protein and extra income in households (Guèye, 2002;

Sharma, 2007). They are a source for reducing malnourishment levels, capital accumulation and a barter product in communities where there is no currency circulation (Guèye, 2009). The eggs and meat are the much preferred products by consumers which have a longer shelf life than chicken eggs and they fetch premium prices compared with commercial chickens and indigenous chickens (Guèye, 1998; Ikani and Dafwang, 2004). Farmers involved in guinea fowl production obtain income from selling live birds and eggs. Live birds are purchased at a retail price of about US$ 4.00 per bird and sold to cafeterias for nearly US$7.50 per bird whilst eggs are purchased at an average price of US$ 3.80 ± 0.55 per crate (2.5 dozen) and sold at approximately US$ 5.70 per crate by traders to cafeterias (Madzimure *et al*., 2011). Guinea fowl meat production has proven to be a viable and profitable enterprise, thus providing opportunity for commercialisation in many parts of the globe (Nahashon *et al*., 2006a).

Guinea fowls greatly contribute to poverty alleviation as they are less expensive and less financial risk as they require minimal attention (Ikani and Dafwang, 2004). The bird is a source of the much needed animal protein in the human diets in developing countries (Adeyemo *et al*., 2006). Eggs and meat are consumed to improve nutrition. This is especially important in infants, pregnant women, the elderly and those in ill health. The taste of guinea fowl meat is more reminiscent of pheasant, without excessive gamey flavour. It is described as very lean, tender and flavourful. Guinea fowl meat is reported to be high in protein and low in fat (CAB International, 1987) hence it poses less health risks to humans. They offer exceptionally high yields at a ratio of 50:50 between meat and carcass, thus they are moist and meaty birds. Eggs are rich in iron, zinc and vitamin

A, all of which are essential to health, growth and well being of humans (Ahlers *et al*., 2009).

Some farmers keep guinea fowls as ‘watch dogs’ due to their ability to sense and see danger. They are kept in some households out of curiosity and for beautifying the homestead with their attractive plumage. They alert other flocks including chickens of predator presence by producing a harsh cry (Mallia, 1999; Smith, 2000). They also control snakes, mice, ticks, other pests and weeds (Frit’s Farm, 2001).

2.4 Guinea fowl production systems

The smallholder poultry sector, which predominantly includes poor rural people (Pedersen, 2002) can be intensive, semi-intensive or extensive. Throughout the continent of Africa the keeping of indigenous fowl by village communities has been practised for many generations (Guèye, 1998). Village chickens have defined production systems whereas guinea fowl production systems in Zimbabwe have not been well defined but the free range system predominates in rural communities. Guinea fowls are generally reared under extensive or semi-intensive systems (Karacay and Sarica, 2004). The intensive guinea fowl procution system employs similar management practices to chickens (Yamak *et al*., 2016)

2.4.1 Intensive system

Guinea fowls in this system are reared with no access to an outdoor enclosure. Raising the poultry in confinement aims to create optimal conditions of temperature and lighting, and in order to manipulate day-length to maximise production. This is in response to meet the high demand of animal protein in the rising urban population of most developing countries (Marangon and Busani, 2006). Huge investments, intensive management, mechanisation and specialisation characterise large-scale poultry production units (Kusina and Kusina, 1999). These requirements confine the large-scale system to a few companies or wealthy individuals (Kusina and Mhlanga, 2000). The intensive system is a high input–high output system. The standard poultry management practices are followed which offer appropriate feeding, housing and health/vaccination programmes.. In guinea fowl production, the intensive production system is mainly practised in developed countries where specialised breeds of guinea fowls have been developed and the production is commercialised (Embury, 2001) for meat and egg production.

Guinea fowls breeder flocks are raised on earthen floors or in battery cages. Flock density of 3 to 5 birds per square metre is used in earthen floors with perches provided in the houses (Moreki, 2009). The modern guinea fowl breeding units are characterised by the battery cage system and artificial insemination. The flock sizes are normally in tens of thousands (Appleby *et al*., 1992) with an area of 12 m × 122 m housing 20 000 birds. The flocks are made up of specialised meat or egg producing hybrids such as broilers and layers (Pedersen, 2002) and are kept on the “all in all out” principle where birds of the same age are kept together.

2.4.2 Semi-intensive system

The semi-intensive system is commonly found in urban and peri-urban as well as rural situations (FAO, 2010). It is similar with the intensive production system as it involves rearing specialised breeds (Kitalyi, 1998). There is provision of permanent housing with access provided to a yard or the surrounding environment with limited space (Fanatico, 1998). Perches are usually provided by farmers and the enclosure is surrounded by a wire fence 1.5 to 2 m high (Moreki, 2009). The housing provoded within the fenced area is for shelter at night and during the heat of the day. Farmers provide the birds with fresh green forage and, water in troughs and there is also supplementary feed. Keets which are expected to be breeders are pinioned to prevent them from flying.

The stocking density has been reported to be up to 500 birds per acre (Embury, 2001). Moreki (2009) reported that 1000 keets during the first three weeks of life require 24 m^2 in a starter house and then are transferrd to a rearing house comprising a 40 m^2 shelter and a 200 m^2 aviary equipped with perches.

The semi-intensive production system is comprised of moderate management level, specialised breeds and is labour intensive (Mapiye *et al*., 2008). To reduce feed costs, most of the farmers under the semi-intensive system have resorted to feeding homemade rations (Tadelle, *et al*., 2003). Disease control is practised, especially vaccinations against diseases of economic importance such as Newcastle disease (ND), infectious bursal disease, Marek's disease and fowl coryza (Muchadeyi, 2007). The level of output in the system is; however, lower as compared to the intensive production system. The housing and fencing provides some protection against predators and theft.

2.4.3 Extensive or scavenging system

Large flocks of guinea fowl birds are left to roam freely over a large area of land. The birds scavenge daily in search for food and water in rangelands, crop fields, and around homesteads predisposing them to predators and disease. Extensive systems are dominated by indigenous poultry breeds, which are not classified into specific breeds and to some extent, have been crossed with other breeds (Pedersen, 2002). This is described as disorderly such that the concept of breed is incorrect (Gue'ye, 1998). The extensive production system is popular in Africa (Moreki, 2009) where farmers may provide minimal inputs in production and low profits are incurred. Birds are offered some housing, or none at all, in which case birds sleep in trees near houses. This low input/output practice has been a traditional component of small farms all over the developing world for centuries and is likely to continue as such in the future. Farmers do not follow standard poultry management practices.

The system is characterised by minimum inputs, with birds scavenging for food, no investments beyond the foundation stock, a handful of grain each day and simple night enclosures (Saina, 2005). The scavenging feed resource base for free ranging poultry is of poor quality and inadequate during the dry season (Saina *et al.*, 2005). In some cases, no housing or shelter is provided (Sonaiya, 1990), if available it is unfit for housing poultry and serves the purpose of housing birds at night.

Guinea fowls are raised under the traditional extensive system by almost all farmers due to its economic and socio-cultural importance. Farmers could be deprived of the full benefit of the birds through the use of feed resources which do not meet the nutrient requirements of the birds, thereby limiting their productivity.

2.5 Constraints to guinea fowl production

Guinea fowls are attractive to small scale farmers due to their adaptability to different environmental conditions (Yamak *et al*., 2016) and they require low production costs. These characteristics are favaourable to the poor and low-income earners found in rural populace who derive sustance from guinea fowls (Obike *et al*., 2011). However, there are various challenges which reduce the productivity and efficiency of indigenous poultry species in the communal production systems (Mwalusanya *et al*., 2002; Abubakar *et al*., 2007). It is important to understand and address the tangible problems and constraints faced by the village poultry keepers to expand and become self-reliant (Tadelle and Ogle, 2001). The major constraints faced by village poultry producers which occur in combination include poor health management, improper housing facilities, inadequate feed resources, high mortality rates, poor access to markets and lack of institutional and infrastructural support. These factors need to be improved on in order for guinea fowls to meet their genetic potential in meat and egg production. Before undertaking any other activity with regards to research and development, there is need for careful analysis and understanding of the farmer's circumstances and production practices (Tadelle and Olge, 2001).

2.5.1 Poor health management

The domesticated guinea fowls are known to be hardy and tolerant to most parasites and diseases which affect production of other poultry species such as chickens and other species. Keets are, however, more susceptible to diseases and parasites (Moreki, 2009). Village poultry are kept under harsh conditions with little or no proper health care provisions which make them susceptible to parasite and disease attacks. There is high infection and transmission of diseases as the poultry species are kept under the extensive system where they roam freely, are mixed with wild species and, exchanged as live birds for breeding stock (Kitalyi, 1998; Olwande *et al*., 2010).

Guinea fowls have not yet been fully domesticated in developing countries hence they still have the hardiness of their wild relatives. They are more tolerant to Newcastle disease (ND) and fowl pox (Chivandi *et al.,* 2002). Newcastle has the ability to cause 100 % mortality in chickens (Alexander *et al*., 2004; Kumaresan *et al*., 2008). Rural households rear chickens and guinea fowls in the same space hence most diseases that affect chickens are highly likely to affect guinea fowls as well (Moreki, 2009). Documented parasites which affect guinea fowls include fleas and round worms, whilst diseases include coccidiosis and trichomoniasis (Table 2.1). Their treatment would require appropriate medication in the form of insecticides, anthelminthics and antibiotics. In cases of disease outbreaks in chickens, guinea fowls are affected as well.

Table 2.1: Common diseases and pests affecting chickens and guinea fowls

	Chicken	Source	Guinea fowl	Source
Pathogens				
Bacterial	*E. coli*, *Samonella spp*, *Salmonella pullorum*, *Salmonella gallinarum*, *Pasteurella multocida*, *Haemophilus paragallinarum*, *Mycobacterium avium*, *Mycoplasma gallispticum* and *Mycoplasma synoviae*	Permin and Bisgaard, 2002	*E. coli*, *Salmonella spp*	Kilonzo-Nthenge *et al.*, 2008
Disease				
Viral	Marek's disease, Avian Avian Leucosis, fowl pox, infectious laryngotracheitis, Infectious bursal disease, ND	Permin and Bisgaard, 2002	Newcastle Disease	Butcher 1999;
Fungal	Aspergillosis and Mycotoxicosis	Permin and Bisgaard, 2002		
Parasitic and pathogenic	Coccidiosis, Histomoniasis, Nematodes, Haemoparasites, Ectoparasites.	Permin and Bisgaard, 2002	Coccidiosis, Trichomoniasis	Downes, 1999
Dietary				
Non-infectious	Deficiencies in Vitamin A, B, D and E and other vitamins, minerals and amino acid	Permin and Bisgaard, 2002		
Parasites				
Ectoparasites	Lice, fleas and mites	Minga *et al.*, 2004	Fleas or lice, mites, soft ticks	Okaema, 1998; Downes, 1999
Endoparasites	Nematodes and cestodes		Roundworms	Downes, 1999

Viral diseases such as Avian Influenza and Newcastle Disease also affect guinea fowl production. An outbreak of a highly pathogenic type of avian influenza (H7N1) in Italy caused mortalities of up to 100 % in chickens and guinea fowls, whereas pheasants and ducks were tolerant (Zanella *et al*., 2001). Another important disease of poultry and other birds, Newcastle disease, was reported to occur naturally in guinea fowls (Aeitken *et al*., 1977; Durojaiye *et al*., 1992; Haruna *et al*., 1993). Bessin *et al.* (1998) reported that bacteria isolated from guinea fowls in surveys included *Escherechia coli*, S*almonella, Klebsiella, Proteus, Pseudomonas* and *Enterobacter. Eimeria* species which causes coccidioisis is an important gastrointestinal parasite (Downes, 1999). External parasites found on guinea fowls are those commonly found on chickens which include fleas, lice, mites and soft ticks (Okaeme, 1988).

The existence of multi-entities and their contact with the outside environment and wild animals makes it difficult to control disease outbreaks (Mapiye *et al*., 2008). Farmers do not keep records and disease epidemiology is poorly understood. However, a reduction in disease losses increases animal production efficiency, and product volume and quality (Garova and Spencer, 1983). High mortality rates caused by diseases can only be improved by instilling proper health control mechanisms and vaccination programmes which have been reported to improve communal chicken production in Pakistan (Javed *et al*., 2003).

In communal production systems, there is inadequate contact with veterinary and extension personnel, which leaves a lot of health problems unnoticed (Muchadeyi *et al*., 2005). The majority of rural framers are unable to access conventional medication to treat their flock and resort to using ethnoveterinary medicines (Muchadeyi *et al*., 2004; Mwale *et al*., 2005) which are readily available locally, low cost, easy to apply and do not require modern technology such as refrigeration (Mapiye *et al*., 2008). Aloe species are the most predominant plant species used by smallholder poultry producers for its antibacterial, antifungal, antivenin and immunological properties (Mwale *et al*., 2005; Mapiye *et al*., 2008). Other plant species used in the control of diseases and pests include *Strychnos spinosa*, *Adansonia digitata*, *Allium sativum* and *Capsicum frutescens* (Pedersen, 2002; Muchadeyi *et al*., 2004; Mwale *et al*., 2005). The use of locally available and cheap ethnoveterinary medicines is probably the most sustainable health management strategy for households with limited resources (Muchadeyi *et al*., 2005). Hence, there is a need for validation of the therapeutic functions, active ingredients and their effectiveness and determination of optimum dosages for various age groups and proper mode of application of ethno-veterinary medicine before their commercial application (Mapiye *et al*., 2008).

Some poultry diseases can be addressed by breeding for disease resistance (Jie and Liu, 2011), an option which can play a noteworthy role alone or together with other control measures which includes disease eradication, vaccination and treatment (Garova and Spencer, 1983).

2.5.2 Improper housing facilities

Adequate housing is a prerequisite in poultry production but usually this is not provided for the birds (Tadelle and Ogle, 2001). Housing provided for village fowls depends on the resources available in the household.

Most farmers provide overnight shelter for their birds and a few leave them outside to roost in trees (Kitalyi, 1999; Kusina and Kusina, 1999; Pedersen, 2002). Housing requirements for keets differ from those of adults and breeding guinea fowls (Saina, 2005). Although Frits Farm (2001) reported that there is no requirement for elaborate and expensive housing for guinea fowl, keets do need adequate protection from predators and harsh environmental conditions (Saina, 2005). There is also a need to provide overnight shelter to protect adult and breeding birds from predation (Embury, 2001; Muchadeyi *et al*., 2007). High mortalities are experienced due to the free movement of birds which also exacerbates spread of diseases and parasites (Muchadeyi *et al*., 2005).

Good sanitation in the housing facility is important in the control of ectoparasites which reduces growth (Chikumba, 2013). The material used for the construction of the shelter may be favourable to feeding and hiding parasites (Mapiye *et al*., 2008). External parasites, such as fleas and mites which suck blood of birds causing irritation and anaemia in birds, brooding hens may abandon shelter resulting in poor hatchability and death of chicks (Mtileni *et al*., 2012). Proper housing should provide birds with adequate ventilation to prevent the spread of diseases and parasites (Hall, 1986), as well as to feed and sleep in comfort and secured environment (Kusina and Kusina, 1999).

2.5.3 Inadequate feed resources

Productivity in poultry production depends mainly on feed. Village poultry scavenge daily in search for feed. Kusina and Kusina (1999) reported that feed shortage is one of the major constraints in rural poultry production. Time allowed to scavenge for food and water is between 0500 to 1800 h, averaging 11 hours per day (Maphosa *et al*., 2004). The birds feed on the available non-conventional feeds which are not used in formulation of poultry feed (Bonds, 1997). Efforts are made to protect field crops during the rainy season (planting season) by letting the birds out of their housing close to midday (Muchadeyi *et al*., 2004). This means that the birds have less time to feed and are prone to physiological stress due to the higher temperatures of the day (Chikumba, 2013). Poor nutrition during the dry season hampers guinea fowl production (Mwale *et al*., 2008).

Supplementary feed is mostly given during the dry periods of the year without measuring amount given to the whole flock which is from a few grammes to 1 kg (Maphosa *et al*., 2004; Atsbeha, 2013). A handful of grain is thrown on the ground to feed guinea fowls which is certainly not more than a supplement (Van Veluw, 1987). This supplementation is sub-optimal and does not meet the bird’s nutrient requirements hence mainly used to tame the birds (Dahouda *et al*., 2007). Supplementation of feed in chickens had been found to improve on flock sizes, growth and fertility rates as well as reduced susceptibility to diseases and parasites (Tadelle and Ogle, 2001; Ogle *et al*., 2004).

The first limiting nutrient in scavenging poultry with regards to chickens and guinea fowls is energy which is supplemented in the form of grains such as maize, sorghum, millet and their by-products (Kusina and Kusina, 1999; Muchadeyi *et al*., 2004; Mwale *et al*., 2008). Protein supply is regarded as not a constraint in the scavenging feed resource (Ogle *et al*., 2004) as guinea fowls are expected to acquire enough of the nutrient from leguminous grains, insects, spiders, worms and snails (Moreki, 2009) whilst supplementation is commonly sunflower (Muchadeyi *et al*., 2004; Mapiye and Sibanda, 2005). This, therefore, poses a question on whether guinea fowls consume sufficient nutrients under this feeding system.

There is competition for the supplementary feed available for all flock ages (Muchadeyi *et al*., 2004) that results in weaker flocks and undernourished chicks (Tadelle and Ogle, 2003). Guinea fowls are known for their ability to utilise a wide range of flora and fauna, cover a great distance from home in search of feed (Nwagu and Alawa, 1995). As they scavenge, feed consumed includes insects, leaves, worms, seeds and bones (Dahouda *et al*., 2007). The competitive advantage of guinea fowls as a free ranging species is a therefore a limitation on meeting the bird's nutritional requirements.

Nutrient requirements of poultry are known to vary according to age, sex and physiological status (Kingóri *et al*., 2007). This may be difficult to meet under the scavenging system where birds consume different quantities and quality of feed. The proportions of feed resource base varies with season, and ecozones as well as activities such as land preparation, sowing, harvesting, grain availability in the household, the life cycles of insects or other invertebrates, and the biomass of the village flock, making it difficult to design appropriate supplementation programmes (Gunaratne *et al*., 1993;

Mwalusanya *et al*., 2002). The instabilities in the supply of feed resources require proper designing of suitable calculated supplementation programmes (Muchadeyi *et al*., 2005). Therefore, timing and frequency of feeding, what, how to feed and quantity to feed are important aspects to consider in developing strategies to improve nutrition of village chickens (Mapiye and Sibanda, 2005).

Water availability to village poultry is not considered as crucial since the birds mostly drink contaminated water found around the homestead or poured to the ground. If birds are supplied with water, the sources are either unprotected or the water trough in a disused dirty container hence contaminated. Guinea fowl production is characterised by poor water availability and quality (Dahouda *et al*., 2007). This might promote the development and transmission of bacterial diseases and other gastrointestinal parasites that may affect the reproduction and productivity of the village poultry (Atsbeha, 2013). Contamination can occur not only in the drinking containers but also at the well or pond sources if not kept clean and sanitary.

Improving guinea fowl egg and meat production is attainable in the free range system through the use of locally available feed resources to meet their nutritional requirements. The types of feed available to scavenging fowl are not known hence, need to research on the types and quality of feed material available for consumption. Such information helps to develop feeding strategies that improve productivity of village poultry.

2.5.4 High mortality and low productivity

The major limitation to indigenous guinea fowl and chicken production has been high mortality especially in keets and chicks under the communal production systems (Pedersen, 2002; Maphosa *et al*., 2004; Saina, 2005; Mtileni *et al*., 2009). It is difficult to associate mortality to a single cause since it is associated with several factors. These factors include diseases, predation, parasites, hostile environment encountered by newly hatched keets and chicks, accidents, nutrient deficiencies, among other factors (Tadelle and Ogle, 2001; Chikumba, 2013). Evidence from experiments on the contribution of each of these factors to overall mortality among household flocks is lacking and difficult to obtain because documentation of death events is rare.

Although guinea fowls are commended for their resistance and tolerance to common poultry diseases, there is high keet mortality experienced. Saina (2005) reported a 64 % keet mortality rate in the Zambezi Valley of Zimbabwe under the traditional management system. Mortality above 50 % in keets has been reported in earlier studies (Nwagu and Alawa, 1995; Bessin *et al*., 1998). In guinea fowls, it was attributed to the susceptibility of keets to adverse weather conditions, diseases and parasites, poor mothering by the guinea fowl hens and poor management (Embury 2001; Saina *et al*., 2003). The major causes of keet and chick mortality are predators such as wild cats, dogs and eagles, low levels of management and external parasites. Flea, lice and mites which hide in overnight shelters are problematic in older birds. Predation, poisoning from agro-chemicals, fights, thefts and poisonous insects are noted to eliminate adult guinea fowls (Saina *et al*., 2005).

In the free ranging system, the newly hatched keets are unable to compete for the same feed resource-base with stronger and more vigorous members of the flock. Due to inability to walk and search for feed, keets are likely to die of starvation. The low protein and energy content of the available feed, low hatching weight of the keets, high ambient temperatures and other associated factors contribute to the losses, both directly, and also by increasing vulnerability to predation and susceptibility to disease (Sonaiya *et al*., 1999, Saina 2005).

Suitable brooding of guinea fowl keets for at least three weeks improves their survival rates (Embury, 2001), as well as disease control on all age groups improves production. Guinea fowl breeders managed to reduce mortality of guinea fowl keets to about 3 % under an improved management system (Galor, 1985).

The high mortality rates, in turn, affect the potential egg output and turnover rate (Chikumba, 2013). The reproductive performance of the village poultry is generally low. The breeding season of guinea fowl occurs during the rainy season, from October to April in the Southern Hemisphere (Kabera, 1997; Embury, 2001). The majority of smallholder farmers use chicken and turkey hens to hatch guinea fowl eggs, as the guinea hen will often leave the nest after only a few guinea keets hatch after the 26 to 28 days of incubation. In the tropics, a guinea fowl hen may lay 50 to 170 eggs per year (Binali and Kanengoni, 1998) of which most of fertile eggs are hatched to replace the keets that die instead of farmers benefiting by selling or consuming them.

2.5.5 Marketing for guinea fowls and their products

A measure of success in a poultry enterprise is done through the product numbers and quality products sold (meat and eggs) (Mapiye, 2008). The increase in guinea fowl production in most countries in southern Africa has resulted in the development of informal markets for mature birds for breeding and consumption especially during the festive season (Saina, 2005). Other guinea fowl products that are found on the market are keets, growers and eggs (Saina 2005). Due to unavailability or unreliability of cold storage facilities in many countries, consumers prefer markets for live birds (Alders, 2014). Trading in the informal sector is done within the local communities, using cash or barter trades between farmers and to several non-farmers that include schools, clinics, business centres and growth points (Harun and Massango, 2000; Muchadeyi *et al*., 2005). The lack of a formal marketing system results in many farmers selling their products through middlemen in the informal sector (Madzimure *et al*., 2011).

Middlemen used by farmers to sell their products benefit more than the farmers in the marketing channel (Mlozi *et al*., 2003). Village poultry fetches higher prices than exotic breeds in the urban areas as they are considered leaner, tastier and suited to the traditional way of prolonged cooking (Pedersen, 2002). Some farmers are forced to consume the birds instead of selling them when they can no longer keep the birds alive to reduce feed costs (Harun and Massango, 2000). Eggs, being perishable, are more consumed in the communal households due to unavailability of markets. The selling of guinea fowl products is done only in the breeding season and this poses as a major limitation to smallholder communal farmers' income (Saina, 2005). The seasonality in the availability of guinea fowl products makes farmers not to consider them as a contributor to improving livelihoods through sourcing income.

Farmers are likely to make the enterprise profitable by first identifying a market for their products before production and establish business contracts with the traders whom they will supply product quantities at specific time frames. Farmers would also benefit by supplying products when the market demand realized favourable prices for them (Moges and Tadelle, 2010).

2.5.6 Institutional and infrastructural constraints

Institutional provision at various levels is essential to cover all factors of village poultry production. Institutional constraints include lack of farm input supply services designed to meet the needs of the smallholder farmers, lack of access to credit facilities and lack of access to profitable urban markets (Mapiye *et al*., 2008). These factors affect the smallholder farmers' confidence, continuity and sustainability of village poultry production.

Guinea fowl farmers in Zimbabwe were reported to obtain information through experience and from suppliers of breeding stock and other farmers (Saina, 2005). Limited knowledge and research on guinea fowl biology and production led to extrapolation of data from chickens. There is risk associated with this because there are genetic and phenotypic differences between these species of poultry (Nwagu and Alawa, 1995).

There is lack of research and education on infrastructure serving the village poultry producers (Chikumba, 2013). Development of these infrastructures will open avenues to farmers by improving service deliveries and market access.

2.6 Carcass characteristics and meat quality of guinea fowls

The yield is affected by numerous factors including strain, sex, age, health, nutrition, body weight, length of feed withdrawal before processing and carcass downgrading (Smith, 1993; Young *et al*., 2001). Poultry producers are more inclined to consider bird strain, sex and age at market that maximises profitability in order to attract consumers (Young *et al*., 2001). These factors influence the carcass yield, internal organs weight and meat quality of the poultry meat. The production of high value parts such as breasts and fillets have become crucial to producers (Shahim and Elazeem, 2005). Indigenous poultry consumption is gaining popularity with the health-conscious consumer mainly in urban areas where these birds fetch higher prices than commercial breeds. Guinea fowls can also contribute to the animal protein sources from indigenous fowls preferred by urban dwellers which is currently dominated by, indigenous chickens.

The birds exist together in rural households hence need to determine how the available resources are translated to the carcass traits and meat quality of the birds. In order to promote production of guinea fowls in households, it is important to assess the yield patterns with reference to the traditional chickens.

2.6.1 Carcass traits

The growth of poultry species is related to the body size. Between poultry species there are significant differences in live weights and carcass measurements caused by genetic and environmental factors (Ogah, 2013). Maturity of the birds is accompanied by muscular tissue growth which is a typical occurrence in time series data. Body weights of guinea fowls increased with age in earlier (Baeza *et al*., 2001; Nahashon *et al*., 2006b Bernacki *et al*., 2013). The birds with higher body weight entail more breast and leg muscles, and carcass remainders (Kokoszynski *et al*., 2011b). Young *et al*. (2001) reported that growth of wings or drumstick was not consistent with age as compared to breast, thighs, fillets and forequarters which increased with slaughter age whilst females were heavier than males in chickens.

Guinea fowls reared under the scavenging production system have variations in their performance. Body weight gain in guinea fowls reared extensively is lower than that of improved strains. The average slaughter age of 16 weeks reported by earlier studies (Robinson, 2000; Embury, 2001; Saina *et al*., 2005) is slowly being invalidated as slaughter age in improved strains can be done at 12 weeks. Laudadio *et al*. (2012) slaughtered guinea fowls at 12 weeks and reported bodyweight of greater than 1900 g, average daily gain of 23 g/d, feed intake of 66.9 g/d and food conversion ratio of 2.8. Body weight averaging 1300g were observed in guinea fowls aged 9 weeks (Nahashon *et al*., 2006b) and. Lower body weights of 1280 g in guinea fowls aged 52 weeks were observed in unimproved guinea fowls in Nigeria (Oke *et al*., 2004). Singh *et al.* (2014) reported body weights ranging from 1220 to 1266 g in 12 week old guinea fowls with

FCR greater than 3.0. Seabo *et al*. (2011) reported body weight of 1.21 to 1.47 kg in 12 week old guinea fowls in Botswana.

Female guinea fowls have recorded higher body weights than males (Kokoszyński *et al*., 2011b; Kasperska *et al*., 2012). Baeza *et al.* (2001) reported that carcass weight of females was greater than that for males by more than 6 %. This is in contrast to previous studies where male guinea fowls were heavier than their female counterparts in pearl gray guinea fowls (Nahashon *et al*., 2004) and French guinea fowl broilers (Nahashon *et al*., 2006b)

Dressing percentages were reported, of 69.4 ± 0. 15 % and 69.6 ± 0.15 % in guinea fowl broilers fed diets containing soybean meal and dehulled-micronized peas (*Pisum sativum*), respectively (Laudadio *et al.*, 2012). Saina *et al*. (2005) observed dressing percentage of 75.4% and 71.6% for guinea fowls kept under the intensive and semi-extensive systems, respectively. Age showed higher dressing percentage in grower guinea fowls aged 13 weeks than 52 week old birds with no significant differences between males and females (Kokoszynski *et al*., 2011b).

2.6.2 Internal organs

During growth and development the internal organs grow in size and some decrease in proportion to live weight with age (Assan, 2013). The proportion of giblets decreases with age (Janiszewska *et al*., 1998). A decrease in the percentage of giblet in guinea fowls was observed in younger bird at ages of 12 and 16 weeks (77.9 ± 6.28 % and 6.4 ±

5.88 %) than at 56 weeks (74.2 ± 4.83 %) (Sharma *et al*., 2000). Increase in abdominal fat with age happens in the majority of bird strains (Ojedapo *et al*., 2008; Murawska *et al*., 2011). Female guinea fowls deposited more abdominal fat than males (Baeza *et al*., 2001, Kokoszyński *et al*., 2011b). The digestive tract weight and length of guinea fowls was observed to increase in males but their proportional weight to body weight increased in females than in males (Kasperska *et al*., 2012). These findings are similar to findings by Kokoszyński *et al*. (2011a), but are in contrast to Kokoszyński *et al*. (2010) where game pheasant males had greater total intestine and small intestine length than females. Indigenous poultry are leaner than modern birds. Domesticated fowl contain less fat (Boncho *et al*., 2003) than waterfowl (Boncho *et al.*, 2005). The weight of the male guinea was heavier (8.75 g) than for females (4.88 g) with opposite results observed for the liver and gizzard (Dahouda *et al*., 2009).

2.6.3 Meat quality

Meat is a source of numerous nutrients and is regarded as a nutrient-dense food. Consumer satisfaction is guaranteed by the quality of the meat. Poultry meat quality is influenced by several factors such as genotype (Fletcher, 1995) and age of animals (Fanatico *et al*., 2005) in meat colour. The values of meat quality traits are given in Table 2.2.

Table 2.2: Chemical composition and some meat quality traits of guinea fowl and different genotypes of chicken breast muscle (*Pectoralis major*)

Parameters	[1]Guinea fowl	Chicken species					
		[2]Broiler	[2]Kabir	[2]*Robusta maculata*	[3]Naked-neck	[3]Ovambo	[4]Thai
Chemical composition							
Moisture (%)	73.25	75.73	77.18	76.01	73.70	72.10	74.88
Protein (%)	23.61	22.76	21.51	22.71	34.90	32.90	22.05
Fat (%)	1.85	0.81	0.67	0.49	10.4	10.60	0.37
Ash	1.29	0.70	0.64	0.79	4.5	4.70	1.03
Shear force value	-	2.69 kg/cm	2.56 kg/cm	2.66 kg/cm	64.00 N	73.50 N	4.09 kg
Cooking loss (%)	-	33.32	37.07	33.28	30.10	34.80	23.00
Meat colour							
L*	47.03	60.03	51.68	57.67	61.20	57.20	42.33
a*	16.15	4.71	5.75	5.71	6.30	8.10	-0.06
b*	3.74	5.58	4.94	7.69	12.70	13.70	4.75

Slaughter age for Ross and Kabir was 81 days and, 120 days for *Robusta maculata* of mixed sex and 2.0-2.9 kg live weights whilst 1.7-2.0 kg live weights were noted for the other birds. Slaughter age was 16 weeks for the other chickens and 12 weeks for guinea fowls, of which, they were all females. Breast muscle (*pectoralis major*) was studied in all the birds.

Sources: Adapted from [1]Laudadio *et al*. (2012); [2]Castellini *et al*. (2002); [3]Chikumba *et al*. (2014); [4]Wattanachant *et al*. (2004)

The breast muscle colour of guinea fowl broilers (Laudadio *et al*., 2012) tends to be darker than that of broiler chickens showing species difference. Redness (a*) of guinea fowl breast muscles was observed to decrease with age guinea fowls and males were redder than females (Kokoszynski *et al*., 2011b). Similarly, breast and thigh muscle of indigenous Padovana chickens was darker than commercial broilers (Polidori *et al*., 1999; De Marchi *et al*., 2005). Older birds meat colour is reported to be darker and redder due to thicker muscle fibre (Bianchi and Fletcher, 2002) or being slow-growing with thinner muscle fibre (Berri *et al*., 2001; Debut *et al*., 2003) and higher myoglobin content (Gordon and Charles, 2002), respectively. Yellowness increases over time when the birds are allowed to forage. Females have yellower meat due to more fat deposition than males whilst males are redder. Kokoszynski *et al*. (2011b) reported higher values of lightness (L*) in breast muscles of 16 week old male and female guinea fowls as compared to 13 week olds. Redness (a*) values were lower in 16 week old than 13 week old birds. Chemical composition of meat is influenced by genotype as Wattanachant *et al.* (2002) and Meluzzi *et al.* (2009) reported that indigenous chickens contain more protein and less fat than broilers. Protein and fat content increases with age whilst moisture content decreases in indigenous chickens (Wattanachant and Wattanachant, 2007; Wattanachant, 2008; Raphulu *et al*., 2015) and improved chicken breeds (Fakolade, 2015) contrary to Tougan *et al*. (2013) findings where protein decreased and moisture increased in local chicken populations of Benin. Physical properties in poultry investigated showed that females had higher cooking loss than males Abdullah and Matarneh (2010) and no differences in water holding capacity. With increase in age, water holding capacity of breast muscles decreased whereas between sexes it was lower in females than in males

(Kokoszynski et al., 2011b). López *et al*. (2011) found no sex difference in broilers for shear force. Shear force values of meat increase with age (Janish *et al*., 2011) due to increase in muscle toughness. The evaluation of scavenging guinea fowls meat in relation to physical and chemical properties has not been done.

2.7 Summary of literature review

Indigenous poultry make great contributions in the improvement of resource poor communities' livelihoods. The production of indigenous chickens is done in synergy with guinea fowls. These are greatly marginalised as less improvement strategies have been put in place to improve their production. Their production is hindered by various challenges in term of health management, feeding and watering, high mortality, low productivity and lack of markets. With the growing human population and health conscious consumers, it is worthwhile to investigate the potential of guinea fowls which is becoming an alternative protein source in rural household, to the popular indigenous chicken. The aim of this research was to determine the effects of age and sex on the carcass characteristics, and meat quality of scavenging guinea fowls.

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Chapter 3: Opportunities for guinea fowl rearing in communal production systems

Abstract

The objective of the study was to identify opportunities and constraints in guinea fowl production in communal production systems. A pre-tested questionnaire was administered to 151 households in 12 wards of Wedza district in Zimbabwe. The majority of the household heads were aged below 55 years. Crops were a main income source to 46.8 % households whilst 9.8 % households depended on livestock as a source of income. The average guinea fowl flock size was 11.36 (SD = 15.44). Guinea fowls were kept as a source of food which was ranked highest (ri = 0.44), followed by income (ri = 0.35). Eggs were considered as the main food followed by meat. About 66.4 % did not practice breeding with the traits selected for included body frame (ri = 0.39), body weight (ri = 0.12) and mothering ability (0.11). Most (97.3 %) farmers supplemented feed using locally available feed resources, whilst 98 % provided water for their flocks. Keets were ranked highest as the age which struggles most from water shortages (ri = 0.45). Mortality causes included predation by birds of prey (ri = 0.31), diseases (ri = 0.22) and wild animal attacks (ri = 0.19). Ethnoveterinary medicines were mostly (68.9 %) used to treat diseases than conventional medicines (51.0 %) by farmers. Lack of capital, feed and predation were the constraints reducing production. Guinea fowls are a tool of alleviating poverty as a potential source of food and income for women who dominated ownership (53.4 %).

Key words: ranking indices, household income, food security, traits of economic importance, constraints

3.1 Introduction

In developing countries, 80 % of the poultry stocks are found in rural communities (Gueye, 2009). Over 80 % of communal households in developing countries own indigenous chickens (Swatson, 2003) of which some farmers keep guinea fowls together with chickens. Among these rural households is found a deficiency in animal protein giving the need to investigate other alternative animal protein sources such as guinea fowls (Obike *et al*., 2011).

Guinea fowls (*Numida meleagris*) are indigenous to Africa and have a distinct popularity among resource-limited farmers (Adjetey *et al.*, 2014). This makes them a promising species in improving acute shortages of animal protein in the continent (Ocheja *et al*., 2010). The birds are adapted to harsh climatic conditions and are tolerant to endemic diseases and parasites (Moreda *et al*., 2014). They require minimal management, making them suitable for rearing by smallholder farmers. In Southern Africa, rural farmers depend on traditional poultry for meeting household needs which are not only socio-economic, but also cultural (Muchadeyi, 2007).

The adoption of guinea fowl production in their rural homesteads to complement chicken production is in its infancy (Saina, 2005). Helmeted guinea fowls are considered to be more tolerant to common poultry diseases and parasites. They utilise a wider range of fauna and flora than other poultry species. Guinea fowl meat is tastier meat than chickens (Koney, 1993). The eggs have thicker shells, which are easier to handle and have longer storage than chicken eggs (Ayorinde, 2004). These characteristics make them suitable for rearing by resource-limited farmers who survive on traditional low input/low output farming systems with minimal provisions for housing, supplementary feed, disease control and prevention (Gondwe and

Wollny, 2007). In addition of them being a tool to improve rural livelihoods, farmers can get encouraged to conserve this natural resource in conservancies close to communal areas (Saina, 2005).

Under the free range system, it is important to determine the extent to which farmers value, support and integrate guinea fowls in their existing farming activities. The objective of this study was to identify management practices, opportunities and constraints of guinea fowl production in communal production systems. It was hypothesised that guinea fowl rearing in communal production systems has huge opportunities to enhance household food security and income generation.

3.2 Materials and Methods

3.2.1 Study site description

The study was conducted in Wedza District located in Mashonaland East Province, Zimbabwe. The district lies between 31º 00´E and 32º 00´E and 18º 30´S and 19º 15´S. The area is characterised by mixed crop and livestock production system under smallholder and semi-intensive farming. The site is located in Natural Region II which receives mean annual rainfall of between 600 and 1000 mm and a mean temperature of 29 °C. The soils in Wedza district are largely derived from granite, with categories on a typical catena recognised as having low soil moisture-holding capacity, high degree of waterlogging, weed burden and soils are of poor fertility. The natural vegetation in Wedza is dry Miombo woodland, with dominant tree species comprising *Brachystegia boehmii*, *B. spiciformis* and *Julbernardia globiflora* (Woittiez, 2010). The Miombo woodland stretches over Mozambique, Malawi and Zimbabwe and varies in density from closed canopy to a savanna with scattered trees (Woittiez, 2010). The dominant grass species found is *Hyperhenia* species (Gadzirayi *et al*., 2007). The major crops grown in the area include maize, groundnuts and sunflower (Zvinorova *et al.*, 2013). Goats, cattle, poultry, sheep, donkeys and pigs are common (Kusina and Kusina, 1998).

3.2.2 Sampling procedure

Twelve wards were randomly selected in Wedza District, from which three villages in each ward were selected. Selection of villages in each ward was done with the help of personnel in the Livestock Production Department (LPD) who were knowledgeable on the distribution of guinea fowl populations in the various villages. Households were selected to participate in the study based on willingness to participate and ownership of guinea fowls. All the farmers who owned guinea fowls were randomly selected to participate in the study. With the use of this criterion, a total of 151 households participated in the study.

3.2.3 Questionnaire administration

Pre-tested questionnaires were administered to randomly selected households who owned guinea fowls. The questionnaires captured data on household sources of income, livestock species kept, crops grown and hectarage, flock and animal herd sizes. The type of data captured and the reasons are given in Table 3.1. Ranking was done by farmers of the sources of income, livestock species kept and crop types grown. Farmers were asked to provide information on the types of dietary supplements they provide for their flocks. Data on challenges faced by farmers in

Table 3.1: Description of data sourced from guinea fowl keepers

Variable	Description	Reason information is required
Demographic data	Household size, household head and age distribution	Helps in identifying active members in guinea fowl production
Income sources	Guinea fowl keepers	Indicates the level of dependency on agriculture activities
Livestock ownership	Numbers of all livestock species owned	Other livestock which share the resources in a household
Guinea fowl flock and ranking among other livestock species	Numbers of keets, growers, hens and cocks	Indicates the breeding flock and their importance in the household
Guinea fowl ownership	Ownership of guinea fowls within the household	Gives technical support systems the household members to target when implementing conservation of genetic resources programmes
Reasons for keeping guinea fowls	Options such as food, income, status among others	Reflects the objectives of the farmers which influence the farmer's willingness to participate in improving management practices
Production systems	Intensive, semi–extensive, extensive	Indicates the level of attention and resource directed to guinea fowls
Management practices	Breeding, nutrition, health and	Gives an understanding of areas needing intervention and causes for some constraints in guinea fowl production
Constraints to guinea fowl production	Feeds, housing, pests, diseases, know-how and others	Highlights the important areas which need improvement on
Opportunities	Positive impacts of guinea fowl noticeable in homesteads	Indicates the potential of guinea fowl production in alleviating poverty

guinea fowl production was captured through the determination of access to veterinary services, predation and disease occurrence and health control practices when diseases occur.

3.2.4 Statistical analyses

The PROC FREQ procedure of Statistical Analyses System (SAS, 2011) was used to estimate the frequencies of qualitative household attributes, household sources of income, incubation method, causes of mortality, egg production, dietary supplementation, opportunities and constraints. The PROC MEANS procedure of SAS (2011) was used to estimate means for land holding size, flock composition and guinea fowl uses. Hatchability was calculated as total number hatched divided by total number incubated.

Ranking indices were calculated to rank livestock species, crop species, sources of income, guinea fowl traits selected for, hardiness of guinea fowls, reasons for keeping guinea fowls and opportunities and constraints which farmers perceived as important. The following formulae were used:

Formula I:

Ranking index (ri) = sum of [5 for rank 1 + 4 for rank 2+ 3 for rank 3+ 2 for rank 4 + 1 for rank 5] for a particular variable divided by sum of [5 for rank 1 + 4 for rank 2+ 3 for rank 3+ 2 for rank 4 + 1 for rank 5] for the variables livestock species, crop species, traits, opportunities and constraints;

Formula II:

Ranking index = sum of [4 for rank 1 + 3 for rank 2+ 2 for rank 3+ 1 for rank 4] for a particular variable divided by sum of [4 for rank 1 + 3 for rank 2+ 2 for rank 3+ 1 for rank 4] for the variables sources of income and functions of guinea fowls and

Formula III:

Ranking index = sum of [2 for rank 1 + 1 for rank 2] for a particular variable divided by sum of [2 for rank 1 + 1 for rank 2] for the variables hardiness and feeding easiness of guinea fowls (Mbuku *et al*., 2006).

Percentage of ranks for each variable was calculated by the formula:

[Number on each rank within a variable] divided by the sum of [Number on each rank within a variable] multiplied by 100.

The association between egg totals, hatchability, production system, breeding practice and qualitative household attributes was determined using the chi-square test. A multinomial regression was used to determine the effect of other livestock ranks on guinea fowls rank. An ordinal logistic regression using PROC LOGISTIC (SAS, 2011) was used to determine the probability of a household to have high total eggs produced and to determine the probability of a household to have high hatchability. The logit function was used to model the relationship between the probability of high egg totals and hatchability occurring and age of household head, vaccination, who manages flock, production system, breeding practices, incubation method, owner, treatment method and supplementation. The logit model used was:

$In(P/(1-P)) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 ...+ \beta_8 X_8 + \varepsilon$

where:

P is probability of a higher egg totals occurring;

is the probability of a higher hatchability occurring;

[P/(1-P)] is odds ratio, which referred to the odds a higher egg totals occurring; is odds ratio, which referred to the odds a higher hatchability occurring;

β_0 is intercept;

$\beta_1 ... \beta_8$ is parameter estimates of age of household head, vaccination, who manages flock, production system, breeding practices, incubation method, owner, treatment method, supplementation; and

ε is random residual error distributed as N (0, $I\sigma^2$ e)

3.3 Results

3.3.1 Household demographics

There were more male headed household (85.5 %) than female headed (14.5 %) households. The majority of the household heads were aged below 55 years with 38.2 % in the range 26 to 40 years. The sources of income included crops, livestock, home industries, salary and remittances from relatives (Table 3.2). Farmers relied mostly on crop and livestock production for income generation. Most farmers (46.8 %) ranked crops as the main source of income with a ranking index of 0.45 whilst one out of 10 farmers depended more on livestock as an income source (ri = 0.31). Salaries, home industries and remittances were considered main contributors to income by 7.3 %, 5.0 % and 1.8 %, respectively. Land holdings averaged 4.15 ha (SD = 2.31) per household

Table 3.2: Frequencies[1] (% of households) and ranking indices (ri) of sources of income

	Frequencies[1] (%)
	% households
Crops	87.42
Livestock	82.78
Home industries	24.50
Salary	19.21
Remittances	18.54

	Rank %				
	*1	*2	*3	*4	ri
Crops	76.87	18.66	4.48	0.00	0.45
Livestock	12.30	62.30	23.77	1.64	0.31
Home industries	30.56	33.33	30.56	5.56	0.09
Salary	50.00	34.38	12.50	3.13	0.09
Remittances	15.38	30.77	50.00	3.85	0.06

[1]Multiple sources of income observed in most households resulted in the frequencies of each source of income percentage to exceed 100 %

with cropping land averaging 3.93 ha (SD = 2.13) and grazing land at 1.83 ha (SD = 0.87). The ranking indices for the livestock species kept and crop species grown are given in Table 3.3. The main livestock species kept were cattle, chickens, goats and guinea fowls. Cattle were ranked highest (ri = 0.27), followed by chickens (ri = 0.25), goats (ri = 0.23) and guinea fowls (ri = 0.20). Maize was the most important crop grown by households (ri = 0.43), followed by groundnuts (ri = 0.25). Tobacco was considered as a better paying cash crop than maize by some (14.3 %) households. A multinomial regression showed that the ranking of cattle, chickens and goats was significant in guinea fowl ranking, whilst the other livestock species were not significant.

3.3.2 Guinea fowl flock composition and reasons for keeping guinea fowls

The guinea fowls were mostly owned by females (53.4 %) with 37.1 % owned by men and the remainder (9.5 %) by children. The mean flock size was 11.36 (SD = 15.44). Hens had the greatest number of 5.99 (SD = 4.83) in the flock compared to cocks (2.51, SD = 1.51), pullets (1.75, SD = 4.08) and keets (1.11; SD = 3.1). Cockerels were had the lowest mean (0.59; SD = 1.51) in the flock. A ratio of one cock to 2.38 hens was observed. Reasons for keeping guinea fowls included eggs, meat, income, beauty, home protection and protecting other flocks (Figure 3.1). Farmers keep guinea fowls mainly for eggs (37.5 %), meat (28.1 %) and 17.1 % as a source of income. Reasons for keeping guinea fowls followed a similar trend where food ranking index was highest (ri = 0.44), followed by income source (ri = 0.35) and social (ri = 0.20 (Table 3.4). Manure was the lowest ranked (ri = 0.01) by the farmers.

Table 3.3: Ranking of livestock and crop species in the communal production systems

	Rank %					
	1	2	3	4	5	ri
Livestock species						
Cattle	93.00	6.00	0.00	1.00	0.00	0.27
Chickens	15.04	21.05	48.12	12.03	3.76	0.25
Goats	14.29	72.38	7.62	5.71	0.00	0.23
Guinea fowls	7.87	17.32	31.50	43.31	0.00	0.20
Ducks	0.00	8.70	21.74	26.09	43.48	0.03
Pigs	50.00	0.00	50.00	0.00	0.00	0.01
Sheep	0.00	0.00	66.67	33.33	0.00	0.00
Other[1]	0.00	0.00	20.00	10.00	70.00	0.01
Crop species						
Maize	88.89	10.42	0.69	0.00	0.00	0.43
Groundnuts	1.75	59.65	34.21	3.51	0.88	0.25
Tobacco	29.79	68.09	2.13	0.00	0.00	0.12
Roundnuts	0.00	14.00	46.00	40.00	0.00	0.08
Small grains	0.00	32.26	58.06	9.68	0.00	0.06
Other[2]	0.00	15.15	36.36	33.33	15.15	0.05

ri = rank index
Other[1] = turkeys, pigeons, rabbits, donkeys
Other[2] = cotton, soyabeans, sweet potatoes, sunflowers, sugar beans, cowpeas

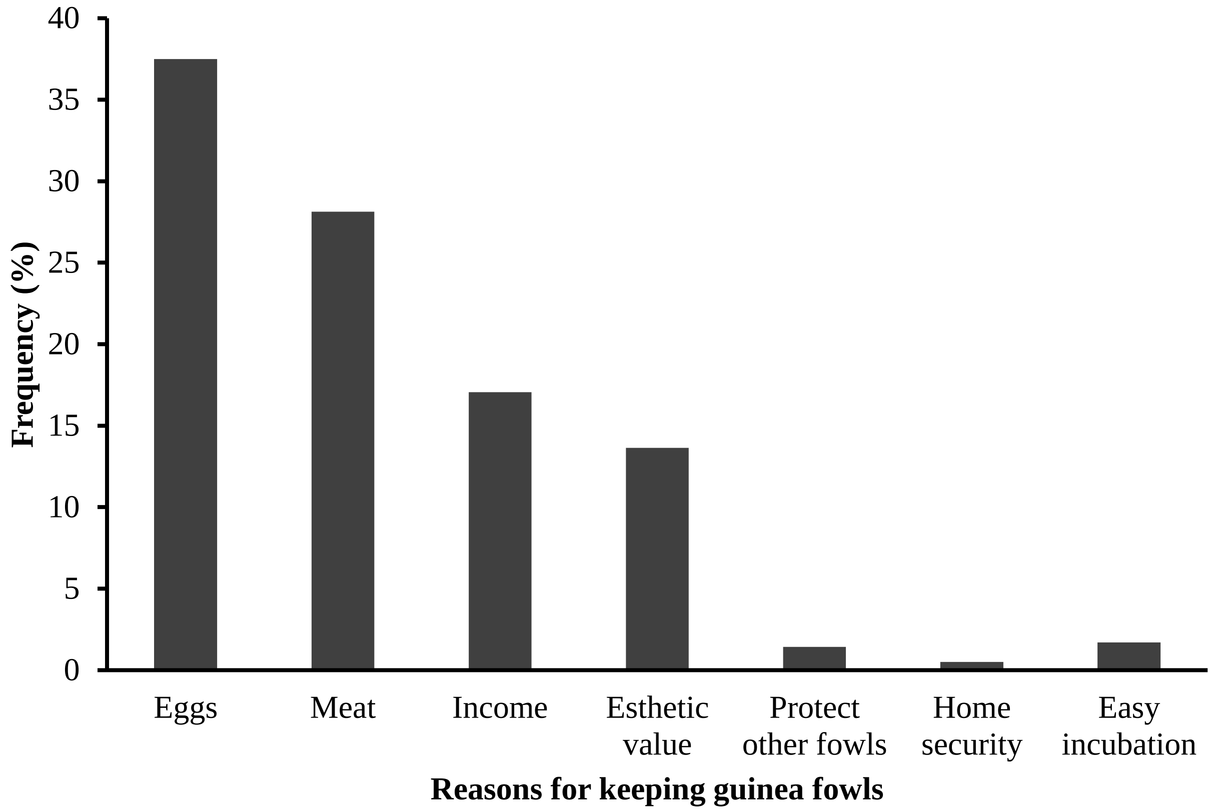

Figure 3.1: Frequencies (%) of reasons for keeping guinea fowls

Table 3.4: Rank index (ri) for functions of guinea fowls

	Rank %				
	1	2	3	4	ri
Source of food	78.15	21.85	0.00	0.00	0.44
Source of income	21.83	76.76	1.41	0.00	0.35
Social functions	2.34	3.13	93.75	0.78	0.20
Beauty	66.67	0.00	0.00	33.33	0.01
Manure	0.00	0.00	0.00	100.00	0.00

3.3.3 Production system and breeding practises

Most of the farmers (88.1 %) kept the guinea fowls under the free range system, followed by semi-extensive (10.6 %) and intensive (1.3 %). Most of the farmers (66.4 %) were not practising any selection in their flock. Those who selected birds for breeding purposes highly ranked traits of body frame (r = 0.39), body weight (r = 0.12) and mothering ability (r = 0.11) (Table 3.5). Total egg production was associated with production system ($\chi^2 = 7.89$, ($P < 0.01$)) and breeding practices ($\chi^2 = 7.89$, ($P < 0.01$) (Table 3.6). The odds of farmers practising selection in their flocks to produce more eggs were higher by four times than farmers not selecting (Table 3.6). The odds of the semi-intensive system to produce more egg totals were 5.8 times greater than the extensive system (Table 3.6). Hatchability was associated to breeding practice ($\chi^2 = 7.87$; $P < 0.05$; Table 3.6). The odds of higher hatchability by farmers who practised selection to higher hatchability were 3.7 times more than for those who did not employ selection practices.

3.3.4 Supplementary feeding

Supplementary feed was offered by 97.3 % of the farmers whilst the rest did not offer anything to the birds. Supplementation was dominated by locally available resources sourced from the previous harvest such as maize, sunflower, small grains and, their by-products which are considered as waste (maize bran and groundnut shells) and kitchen wastes. Majority of farmers (98.6 %) offered the same feed to both guinea fowls and chickens and other flocks in the homestead. Feed was thrown on the ground by 84.1 % of the farmers and 15.9 % placed it in containers. Water was provided by (98 % households whilst 2 % left their flocks to search for water. Keets were noted to struggle most from water shortages (ri = 0.45), followed by hens (ri = 0.31) and cocks (ri = 0.24).

Table 3.5: Rank index (ri) for guinea fowl traits selected for by farmers

	Rank %					
	1	2	3	4	5	ri
Body frame	94.59	5.41	0.00	0.00	0.00	0.39
Body weight	0.00	92.86	7.14	0.00	0.00	0.12
Mothering ability	33.33	50.00	16.67	0.00	0.00	0.11
Plumage colour	40.00	50.00	10.00	0.00	0.00	0.09
Egg number	18.18	36.36	45.45	0.00	0.00	0.09
Egg size	20.00	80.00	0.00	0.00	0.00	0.04
Survivability	0.00	80.00	0.00	20.00	0.00	0.04
Disease tolerance	0.00	50.00	16.67	16.67	16.67	0.04
Drought tolerance	0.00	60.00	20.00	0.00	20.00	0.03
Meat quality	0.00	100.00	0.00	0.00	0.00	0.03
Heat tolerance	0.00	100.00	0.00	0.00	0.00	0.03
Egg colour	100.00	0.00	0.00	0.00	0.00	0.01

Table 3.6: Egg total and hatchability as affected by production system and breeding practice and odds ratio estimates

	Wald Chi-square (χ^2)	Pr > Chi-square	
Egg total			
Production system	7.39	0.01	
Breeding practice	7.11	0.01	
Hatchability			
Breeding selection practice	7.87	0.05	
	Odds ratio estimates		
Parameter	Odds ratio	Lower CI	Upper CI
Egg total			
PS Semi extensive vs extensive	0.17	0.05	0.61
Breeding practice yes vs no	0.24	0.01	0.69
Hatchability			
	Odds ratio	Lower CI	Upper CI
Breeding practice yes vs no	0.27	0.111	0.676

PS = production system

3.3.5 Health and mortality

Causes of mortality indicated were predation by birds of prey with the highest rank index (ri = 0.31), followed by diseases (ri = 0.22) and wild animal attacks (ri = 0.19). Other causes of mortality included cats and dogs attacks (ri = 0.09), cold and hot weather and mites. Keets were reported to be adversely affected by weather conditions especially during the rainy season by 87.6 % of the farmers. Diseases which were highlighted were coccidiosis (66.2 %) and Newcastle disease (58.4 %). Vaccination of the guinea fowls was done by 62.9 % through vaccination programmes carried out by the government veterinary officers when a disease outbreak occurred. Farmers treated their guinea fowls with either traditional or conventional medicines. Ethno-veterinary medicines were used by 68.9 % of the farmers and 51.0 % used conventional medicines. The common ethno-veterinary medicines used were Aloe species and *Capsicum frutescens* (hot peppers) known as '*mhiripiri*' in Shona language.

3.3.6 Opportunities and constraints to guinea fowl production

Guinea fowls were reported by farmers to have made a positive impact in their livelihood in improving nutrition (99.3 %) and income (94.6 %). A positive impact of guinea fowl rearing on the protection of other fowl was reported by 98.0 % of the farmers whilst 59.5 % used income from guinea fowls as capital for other livestock species in their homesteads. Uses of guinea fowls in a homestead averaged 2.3 (SD = 1.03), with three uses indicated by 30.5 % of the farmers, two uses by 29.8 % and one use by 27.8 %. The meat of guinea fowls was reported to be tastier than chicken meat by the majority of the farmers (78.6 %). Guinea fowls were reported to be easier to feed (ri = 0.57) and hardier (ri = 0.65) than the traditional chickens (ri = 0.43; ri = 0.35) by farmers. All the households (100 %) kept guinea fowls together with chickens and other poultry species such as turkeys. Chicken hens were used as incubators for guinea fowl eggs until they hatched.The major constraints were predation (r = 0.24) as the highest ranked, followed by lack of capital (r = 0.23) and feed (r = 0.21) (Table 3.7). Capital was highly ranked as it influences the other lowly ranked constraints such as housing, medication and market. The lack of knowledge contributed 14.6 % to rank percentage. The marketing of the birds was done informally by all the farmers.

Table 3.7: Rank index (ri) for major constraints facing guinea fowls

	Rank %					
	1	2	3	4	5	ri
Predation	53.33	16.67	23.33	5.56	1.11	0.24
Lack of capital	40.91	28.41	23.86	6.82	0.00	0.23
Lack of feed	29.47	26.32	7.37	24.21	12.63	0.21
Lack of knowledge	19.35	35.48	33.87	11.29	0.00	0.15
Housing	35.71	46.43	17.86	0.00	0.00	0.08
Thefts	8.89	11.11	2.22	17.78	60.00	0.06
Medication	45.45	27.27	9.09	9.09	9.09	0.03
Accidents	66.67	0.00	0.00	33.33	0.00	0.01
Market	0.00	50.00	50.00	0.00	0.00	0.00
Low egg production	100.00	0.00	0.00	0.00	0.00	0.00

3.4 Discussion

The production of village poultry in Southern Africa is a common practice especially in communal areas since they have been culturally accepted (Mutenje *et al*., 2009). Guinea fowls are kept in synergy with indigenous chickens as they require low or no inputs in production in terms of housing, supplementary feeding, management and disease control (Alders and Pym, 2009).

The finding that the majority of the guinea fowls were owned by women agrees with Moreki *et al*. (2010). Similarly as in chickens, ownership was inclined to women irrespective of the household head's gender (Muchadeyi *et al*., 2004; Halima; 2007, Mwale and Masika, 2009). Most women are left to take care of homesteads, in tasks and responsibilities in crop and livestock production (Gueye, 2003) while the males are away, sourcing needs for the household members. In contrary Saina (2005) found more male guinea fowl owners in Guruve, Zimbabwe which was attributed to difficulties in catching and holding guinea fowls by women as they are strong fliers (Oke *et al*., 2004). Women, can use guinea fowls in ways similar to chickens in poverty alleviation and economic empowerment since most of them are not employed (Moreki and Seabo, 2012).

The fairly young population in the current study took a more active role in poultry production which shows that guinea fowl contributes in the improvement of rural livelihoods. Teye and Adam (2000) reported similar findings where relatively younger and energetic farmers reared guinea fowls as they are still able to carry out various farming activities. However, Sonaiya

(2007) included the aged people as an important age class which cared for most of rural poultry species, which contradicts with the findings in the current study.

The mean guinea fowl flock size of 11.36 observed is similar to that observed in Gokwe and Mberengwa districts (Gono *et al*., 2013) and higher than 8 guinea fowls per household in Guruve district (Saina, 2005). Saina (2005) reported a sex ratio of 1.38 hen to one cock, lower than the observed 2.81 hen to 1 cock. This indicated a high level of inbreeding since the ratio of one cock to four productive hens gives good fertility (Nwagu and Alawa, 1995). The variations in the flocks depend on the production system, management and environment. Guinea fowls are an emerging poultry species and considered to be an alternative to the traditional chickens which have similar uses in the household. Adjetey (2006) reported that households usually keep small numbers of guinea fowls as a protein source for their families. Generally, poultry species are kept in low numbers in households to ease management and are kept for consumption. The main reason for keeping guinea fowls was for food. There are hardly any cultural barriers to consumption of guinea fowl products (Saina *et al*., 2005) making their contribution significant in human nutrition. Eggs and meat of guinea fowls are high in protein, a major limiting nutrient in growth. Eggs were considered as more important than meat contrary to findings by Saina (2005) where farmers barter traded egg with surrogate chicken hen for incubation eggs. Income generated from selling of live birds and eggs were used for household needs such as school fees, food, medication and as petty cash in homesteads. Uses in customary activities were not reported by farmers in this study as in Ghana (Teye and Adam, 1999; Dei and Karbo, 2004) and Malawi (Gondwe, 2004).

Mallia (1999) reported that guinea fowls are kept in the scavenging system in most developing countries which results in low productivity. The scavenging system is suited to the birds as they have a better ability to scavenge for food than chickens and the level of management is low (Ikani and Dafwang, 2004; Saina, 2005).

Production of guinea fowls is similar to chickens in that it is a sideline enterprise requiring less labour and land resources hence given little attention (Mwale and Masika, 2009). Guinea fowls are thought to perform better under the semi-extensive system (Naazie *et al*., 2007, Teye and Gyawu, 2002) than the extensive system as represented by the probability to improve egg production in this study. Farmers as observed in this study therefore may need to move away from the scavenging production system as it predisposes birds to predation and infections. Selecting for body frame and weight by farmers in this study makes great sense as they keep the birds to provide meat. Mothering ability was noted as crucial as guinea fowl hens are poor mothers whose eggs are incubated by chicken hens (Ajala *et al*., 2007; Gono *et al*., 2013). Breeding of guinea fowls occurs in the free range, as they search for feed and water and overnight housing when they are crowded (Boko *et al*., 2011) making the selection process difficult in a flock. Findings of more egg totals in the semi-intensive production system in the current study confer to earlier findings (Saina, 2005). Breeding practices were found to improve egg totals and hatchability in this study which is supported by Dahouda *et al.* (2007) who attributed low productivity in guinea fowls to inbreeding in the free range system.

Dietary supplements given to guinea fowls were fibrous crop by-products. The birds scavenge for most of their daily nutrient as they feed on mainly weeds, grasses, insects and waste grains in the wild (Adeyemo and Oyejola, 2004). As such, nutrients available to scavenging birds depends on type and quality of the scavengeable feed resources, season and reproduction stage. Farmers provided water as they were aware of the ages of birds which struggled with water although the water provided was unhygienic.

With the belief that guinea fowls are tolerant to diseases, farmers were not forthcoming when it came to health management. Coccidiosis and Newcastle disease reported in the study are among the common diseases in guinea fowls observed in earlier studies (Teye and Adam, 1999; Tye and Gyawu, 2001; Moreki *et al*., 2011).The possible occurrence of Newcastle disease in their flocks requires proper health care which the farmers were not prepared to give to the birds. They resorted to the use of traditional medicines that are a form of remedy among resource poor farmers (Ernst, 1998, Saina 2005; Mwale and Masika, 2009). This gives an understanding that the farmers cannot afford to source conventional medication as they have limited resources to use for all their farming activities. Vaccination of flocks was left as a responsibility of the government veterinary services. External parasites which mainly affect keets and breeding hens observed are major health concern in free ranging guinea fowls (Moreki *et al*., 2010). Small stocks require minimal input to multiple in numbers justifies the lack of need to improve their health care.

Guinea fowl production is an important tool similar to chickens, in poverty alleviation and improving protein quality in poor communities (Mapiye *et al*., 2008; Moreki and Seabo, 2012) as indicatied by the number of uses households had for guinea fowls in this study. There was more reliance on guinea fowls for food security than income as indicated in earlier findings (Saina, 2005; Moreki, 2009). Smith (1990) noted that guinea fowls can be kept for both egg and meat production. Eggs are used as relish when other relish supplies are low in the households. Guinea fowls are used in barter trading for goods and services in most rural communities in Africa. Although the birds have multiple purposes, their role in improving the economics of households is not significant. They exist in synergy with chickens which are used as egg incubators (Dahouda *et al*., 2007) which reduces egg wastages as chickens are reared by nearly every rural household. Adoption of guinea fowl rearing is easier in the rural communities as it requires less capital, space and labour, hence suitable for even the landless rural dwellers (Moreki, 2009). This is advantageous to women who hold lower status in most societies due to patriarchal values (Gueye, 2000).

Hardiness and ease of feeding guinea fowls reported in this study is supported by the observations that they have the ability to cover longer distances in search of feed hence feeding on a wide range of flora and fauna including insects and grains, better resistance to most common poultry diseases such as Newcastle disease and fowl pox and ability to protect itself from predators (Microlivestock, 1991). Embarking on guinea fowl production by rural farmers will therefore, widen their capacities to secure food and income from additional poultry species to the traditional chickens. Koney (1993) noted that as compared to chicken meat, guinea fowl meat is tastier and firmer with higher edible meat yields. The flavour of the meat resembles that of wild game a characteristic that fetches premium prices (Embury, 2001; Moreki, 2009). The foregoing advantages and importance of the bird have enticed many farmers to take special interest in their production.

Constraints indicated by farmers affect the level of guinea fowl production. Predation as the major concern is attributed to the free ranging system as farmers have no control of the birds' movement as they scavenge for feed (McAnish *et al*., 2004). This free movement also exposes the birds to pests, diseases, and harsh weather conditions. Predation accounts for loss of eggs and mortalities especially in keets (Teye and Adam, 1999). Farmers can improve the number of birds kept when they have enough capital to cater for health, housing and feed. Without optimum provision of these practices, their potential will not be realised due to slow growth rate, low egg production, high predation, mortalities and parasitic attacks (Phiri *et al*., 2007; Mungube *et al*., 2008). There is need to provide technical support to improve guinea fowl production as it is a promising genetic resource for resource poor farmers in developing countries in reducing poverty (Teye and Gyawu, 2002).

3.5 Conclusions

The main role played by guinea fowls in resource-limited communities is the provision of eggs and meat. Women are the major owners of guinea fowl who also acquire income from the birds' products. The odds of higher egg production are more under semi-extensive system than extensive. Farmers that practised selection in their flocks had higher egg production than those who did not. Households rely on guinea fowls for food and income to alleviate poverty. Households found two or more uses for guinea fowls in their homesteads including food and income. Farmers kept guinea fowls in synergy with chickens as they require the same management. There is therefore, need to investigate the carcass traits as influenced by age and sex of both scavenging guinea fowls and chickens kept under the free range system.

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Chapter 4: Effect of age and sex on carcass characteristics and weights of internal organs in scavenging helmeted guinea fowls

Abstract

The objective of the current study was to determine the effect of age and sex on carcass characteristics and internal organ weights in scavenging guinea fowls. Forty eight scavenging helmeted guinea fowls, purchased from farmers were used comprising 21 growers and 27 adults. In addition, 48 scavenging chickens comprising 19 growers and 29 adults were used as a benchmark with no statistical comparison with guinea fowls. Growers were four to eight months old and adults were one year old. Adult guinea fowls had higher ($P < 0.05$) body weight, relative hot carcass weight and cold dressed weight than for growers. There was no influence of sex on body weight and carcass weight. Growing guinea fowls had significantly heavier relative weights of leg than adults (114.8 ± 3.66 versus 92.2 ± 3.38 g/kg BW), respectively. The thigh was also heavier in growing birds than adults. Similarly, the relative weights of the drumstick was lower in adults than growers (41.1 ± 1.57 versus 50.1 ± 1.70 g/kg BW). Breast weight in males (198.7 ± 5.37 g) was heavier ($P < 0.05$) than in females (178.8 ± 6.25 g). There was no significant effect of age and sex on relative wing weight. Relative abdominal fat weight was higher in adults ($P < 0.05$) (24.5 ± 0.57 g/kg BW) than in growers (20.7 ± 0.62 g/kg BW). Females had significantly higher abdominal fat weight than males. Back weight in adults was 148.7 ± 6.02 g as compared to 120.6 ± 6.52 g in growers ($P < 0.05$). Growers had heavier ($P < 0.05$) weights of kidney than adults (8.7 ± 0.41 versus 6.6 ± 0.35 g/kg BW). The heart, lungs and gizzards were also heavier in growers than adults. Age and sex had no effect ($P > 0.05$) on the spleen weight. Total intestine length in growers (113.2 ± 4.15 cm/kg BW) was longer ($P < 0.05$) than in adult (74.3 ± 3.90 cm/kg BW). Growing birds had longer ($P < 0.05$) small intestines and large intestines than adult birds. No sex differences ($P > 0.05$) were observed for intestinal length

measured. It can be concluded that age and sex influence organ weights and weight of saleable parts of the bird.

Key words: guinea fowl, age, sex, scavenging, carcass characteristic, internal organs

4.1 Introduction

Traditional free range poultry is of great importance in smallholder communal production systems. Village poultry in Southern Africa include chickens, guinea fowls, turkeys, geese, and pigeons (Delany, 2003). In most developing countries, poultry production is based mainly on scavenging systems which has been a traditional component of smallholder farmers in the developing world for centuries and is thought to continue in the future. In the scavenging production system, guinea fowls complement village chicken enterprises by utilising spaces and feeds that are accessible to chickens. They also produce more eggs than chickens, although they are poor brooders (Van Veluw, 1987). Data on the interface and synergy between scavenging chickens and guinea fowls is scarce (Poulsen, 2000; Obike *et al*., 2011). Popularising guinea fowls as a source of quality meat and cheaper animal protein is important (Singh *et al*., 2014).

Guinea fowl provide meat is which is highly acceptable in many resource-poor communities under the free range production system with minimal inputs offered. The slaughter age in European guinea fowl strains of 82 days in the intensive system and about 94 days under free range (Pudyszak *et al*., 2005) are not comparable to more than one year required to reach maturity in unimproved guinea fowls. Understanding the carcass and internal organs yield in guinea fowls in response to age and sex is key for the promotion of their commercialization in developing countries. Carcass weight gives a clearer picture of benefits form the animal rather than live weight which only predicts amount of edible products such as muscles (Mohammed *et al*., 2012). Proportions of muscles, bones, fat and connective tissues in relation to carcass yield give carcass composition. Body weight, dressing percentage and carcass composition in earlier studies are affected by genotype (Leterrier *et al*., 1999; Baeza *et al*., 2001) , age (Porwal *et al*., 2002; Pudyszak *et al*., 2005; Mareko *et al*., 2008) and sex (Leterrier *et al*., 1999; Baeza *et al*., 2001). Additional factors affecting the above traits include housing system (Mareko *et al*., 2006; Mareko *et al*., 2008) and diet composition (Adeyemo and Oyejalo, 2004; Laudadio *et al*., 2012). Kokoszynski *et al*. (2011b) observed an increase in body weight between 13 and 16 week old guinea fowls. Also, females yielded heavier carcasses and abdominal fat than males in the study.

Information on the comparisons of growth, carcass and carcass portions in scavenging guinea fowls is limited (Kokoszynski *et al*., 2011b; Mohammed *et al*., 2012). Such comparisons enable policy-makers and development agencies to develop informed strategies of improving smallholder poultry production systems. Guinea fowls and chickens are kept together by communal farmers in the free range system as indicated in Chapter 3. Therefore, the objective of the current study was to determine the effect of age and sex on carcass characteristics and internal organs in scavenging helmeted guinea fowls. It was hypothesised that carcass and internal organ weights varies with age and sex in helmeted guinea fowls. Chickens were included in the study as a reference population and not statistically compared with guinea fowls in this study.

4.2 Materials and Methods

4.2.1 Description of study site

The study was conducted in Wedza District communal area located in Mashonaland East Province, Zimbabwe. The description of the study site is given in Section 3.1.

4.2.2 Bird sampling and slaughter

A total of 96 birds were used in the study. Forty eight helmeted guinea fowls and 48 chickens were purchased from different guinea fowl and chicken keepers of Wedza district in Zimbabwe. Chickens were used as a reference population with no statistical comparison with guinea fowls. Guinea fowls comprised 25 females and 23 males made up of 21 growing (11 females and 10 males) and 27 adults (14 females and 13 males). Chickens had 18 females and 30 males with 19 growers (7 females and 12 males) and 29 adults (11 females and 18 males). Growing birds were aged between four to eight months which were weaned at about three months of age when they would have gained maturity weight. Adult birds were above one year with the hens considered to have at least gone through one cycle of laying (Mwalusanya *et al*., 2002). The birds used in the study were those which were left to roam freely and scavenge during the day and confined at night as described by Mwalusanya *et al*. (2002). The birds were occasionally given cereal grains such as maize and sorghum, leafy vegetables and kitchen waste as supplementary feed of unmeasured quantities. Sampling of the chickens and guinea fowls was done from March to April 2015 nearing the end of the rainy season when the plane of nutrition was high and farmers harvesting field crop. At each sampling time, the birds were caught from the households at the end of day when doing their last scavenging and slaughtered immediately between 1600 and 1800 h by the same person. The birds were slaughtered by cervical dislocation and slitting of throat using a sharp knife and left to bleed for five minutes (Ncobela *et al*., 2016). After bleeding, the carcass was scalded in hot water for a few minutes to allow for manual plucking of feathers. The birds were eviscerated. The head was removed between the occipital condyle and the atlas and the feet at the carpal joint. The carcass, head, feet and internal organs for each bird were placed in separate labelled polythene bags, placed in a cooler box filled with ice and transported to the University of Zimbabwe, Animal Science Department Laboratory for carcass measurements.

4.2.3 Measurements

All the measurements taken from each carcass, except for the body weight and intestinal length were expressed relative to the live body weight as g/kg BW. Intestinal length was expressed as cm/kg BW. Measurements of the body weight (BW), hot carcass, head and feet were done using a mechanical top loading scale which weighs up to 5 kilograms in 20 grams increments (Salter Model 250-6S). The carcass was weighed again after 24-hour refrigeration at 4 ºC to determine cold carcass weight. The carcass was cut into breast, legs (including thigh and drumstick), wings, back and neck. The cut parts of economic importance comprised the wing, leg, thigh, drumstick and breast were cut according to the method used by Goliomytis *et al*. (2003). Carcass remainders were the back, neck, feet and head. Internal organs were referred to as giblets (heart, liver, lungs, kidneys, spleen, total intestines and gizzard) and abdominal fat were separated and weighed using a Mettler PE 2000 digital electronic scale with an accuracy of 0.1 g. The length of the intestines was measured using a flexible tape measure with an accuracy of 1 mm.

4.2.4 Statistical analyses

Analysis of variance was carried out to determine the effects of age and sex and their interactions on carcass characteristics and internal organ weights of guinea fowls using the PROC GLM procedure of SAS (2011). The model used was:

$Y_{ijk} = \mu + A_i + S_j + S_k + (A \times S)_{ij} + \varepsilon_{ijk}$

where:

Y_{ijk}	= response variable (carcass and internal organ weights);
μ	= overall mean common to all observations;
A_i	= effect of the i^{th} age (i = growers, adults);
S_j	= effect of j^{th} sex (j = male, female);
$(A \times S)_{ij}$	= effect of interaction between i^{th} age and j^{th} sex;
ε_{ijk}	= random error with mean 0 and variance σ^2

Least square means were calculated and separated using the LSMEANS and PDIFF procedure of SAS (2011).

4.3 Results

4.3.1 Body weights, hot carcass and cold carcass weights

Table 4.1 shows the levels of significance for the carcass traits and internal organs measured in scavenging guinea fowls. The poultry species were presented together with no statistical comparison between species. Chickens were used as a benchmark for findings in guinea fowls. In guinea fowls, age had an effect on absolute body weight and proportional weights of the cold carcass relative to body weight. Body weight (1543.6 ± 33.1 g), relative hot carcass weight (693.3 ± 9.20 g/kg BW) and cold dressed weight (673.1 ± 11.40 g/kg BW) in adult guinea fowls was higher ($P < 0.05$)

Table 4.1: Levels of significance for carcass traits and internal organs in scavenging guinea fowls and chickens

	Guinea fowls			Chickens		
Trait	**Age**	**Sex**	**Age × Sex**	**Age**	**Sex**	**Age × sex**
Final BW/g	***	Ns	ns	***	ns	ns
Hot carcass (g/kg BW)	**	Ns	ns	ns	*	*
Cold dressed (g/kg BW)	*	Ns	ns	*	*	ns
Wing (g/kg BW)	ns	Ns	ns	ns	ns	ns
Leg (g/kg BW)	***	Ns	ns	*	ns	ns
Thigh (g/kg BW)	***	Ns	ns	**	ns	ns
Drumstick (g/kg BW)	**	Ns	ns	ns	ns	ns
Breast (g/kg BW)	ns	*	ns	***	ns	ns
Neck (g/kg BW)	***	Ns	ns	ns	ns	ns
Back (g/kg BW)	**	Ns	ns	ns	ns	ns
Feet (g/kg BW)	***	Ns	ns	ns	ns	ns
Head (g/kg BW)	***	Ns	ns	***	ns	ns
Abdominal fat (g/kg BW)	***	**	ns	**	***	ns
Gizzard (g/kg BW)	*	Ns	*	ns	ns	ns
Liver (g/kg BW)	***	Ns	ns	*	ns	ns
Heart (g/kg BW)	*	Ns	ns	ns	ns	ns
Lungs (g/kg BW)	***	Ns	ns	**	ns	ns
Kidney (g/kg BW)	***	Ns	ns	***	ns	ns
Spleen (g/kg BW)	ns	Ns	ns	ns	ns	ns
Total intestine (g/kg BW)	ns	Ns	ns	*	ns	ns
Total intestine (cm/kg BW)	***	Ns	ns	***	ns	ns
Small intestine (cm/kg BW)	***	Ns	ns	***	ns	ns
Large intestine (cm/kg BW)	**	Ns	ns	**	ns	ns

*P < 0.05; **P < 0.01; ***P < 0.001; ns – not significant (P > 0.05) than 899.8 ± 35.86 g, 647.5 ± 9.96 g/kg BW and 630.5 ± 12.34 g/kg BW, respectively for growers. Grower guinea fowl females (973.8 ± 61.47 g) and males (920.8 ± 55.71 g) showed lower ($P > 0.05$) body weights than adult females (1628.6 ± 48.58 g) and males (1664.8 ± 54.76 g) (Table 4.2). There was no influence of sex and interaction of age × sex on body weights ans carcass weights. In chickens age had an effect on body weight and cold dressed weight whilst sex had an effect on hot carcass and cold dressed weights (Table 4.1). An interaction of age × sex was observed for hot carcass weight. The mean weights in chickens were lower than those observed in guinea fowls as shown in Table 4.2.

4.3.2 Cuts of economic importance

Table 4.3 shows the relative breast, leg, thigh, drumstick and wing weights for scavenging guinea fowls and chickens. Age had a significant effect on guinea fowl leg, thigh and drumstick relative weights. Growing guinea fowls had significantly heavier relative weights of leg (114.8 ± 3.66 g/kg BW), thigh (67.6 ± 2.24 g/kg BW) and drumstick (50.1 ± 1.70 g/kg BW) as compared to values of 92.2 ± 3.38, 54.2 ± 2.06 and 41.1 ± 1.57 g/kg BW for leg, thigh and drumstick in adults, respectively. Males had heavier ($P < 0.05$) breast weight of 198.7 ± 5.37 g compared to 178.8 ± 6.25 g in growers. There was no significant effect of age, and sex on relative wing weight. In chickens, breast weight of adults (143.8 ± 3.13 g/kg BW) was higher ($P < 0.05$) than in growers (113.8 ± 4.13 g/kg BW). Leg and thigh weights in chickens were also higher ($P < 0.05$) in adults than growers (Table 4.3). Generally, chickens had higher values for leg, thigh and drumstick weight than guinea fowls and vice versa for breast and wing (Table 4.3).

Table 4.2: Effect of age and sex on body weight, hot carcass weight and cold dressed weight of scavenging birds

Trait	Species	Grower female	Grower male	Adult female	Adult male
Body weight (g)	Guinea fowl	973.8 ± 61.47^{b}	920.8 ± 55.71^{b}	1627.6 ± 48.58^{a}	1664.8 ± 54.76^{a}
	Chicken	878.8 ± 66.21^{b}	905.0 ± 59.72^{b}	1416.3 ± 60.00^{a}	1557.3 ± 43.84^{a}
Hot carcass (g/kg BW)	Guines fowl	663.6 ± 13.24^{bc}	631.4 ± 12.00^{c}	686.6 ± 10.47^{ab}	702.0 ± 11.80^{a}
	Chicken	586.5 ± 14.27^{b}	645.2 ± 12.87^{a}	654.6 ± 12.92^{a}	652.0 ± 9.52^{a}
Cold dressed (g/kg BW)	Guinea fowl	640.5 ± 14.30^{b}	618.5 ± 12.96^{b}	658.7 ± 11.31^{ab}	688.3 ± 12.74^{a}
	Chicken	586.5 ± 15.41^{b}	624.7 ± 13.90^{a}	636.5 ± 14.00^{a}	640.4 ± 10.20^{a}

^{abc}Within trait and species, least square means with different superscripts differ ($P < 0.05$).

Table 4.3: Effect of age and sex on cuts of economic importance (g/kg BW) in scavenging birds

Trait	Species	Grower female	Grower male	Adult female	Adult male
Breast	Guinea fowl	167.5 ± 7.21^{b}	197.1 ± 6.56^{a}	201.3 ± 5.70^{a}	198.0 ± 6.42^{a}
	Chicken	110.5 ± 7.79^{c}	119.0 ± 7.00^{bc}	134.4 ± 7.60^{ab}	146.1 ± 5.14^{a}
Leg	Guinea fowl	110.1 ± 4.61^{a}	120.1 ± 4.18^{a}	89.6 ± 3.64^{b}	91.3 ± 4.11^{b}
	Chicken	112.8 ± 4.97^{b}	114.9 ± 4.48^{b}	126.6 ± 4.50^{ab}	127.7 ± 3.29^{a}
Thigh	Guinea fowl	66.3 ± 2.96^{a}	70.4 ± 2.68^{a}	50.5 ± 2.34^{b}	54.6 ± 2.63^{b}
	Chicken	56.7 ± 3.184^{b}	57.8 ± 2.872^{b}	67.8 ± 2.88^{a}	68.8 ± 2.11^{a}
Drumstick	Guinea fowl	46.9 ± 2.20^{b}	53.6 ± 1.99^{a}	40.6 ± 1.74^{c}	40.6 ± 1.96^{c}
	Chicken	56.1 ± 2.37^{a}	57.8 ± 2.14^{a}	57.5 ± 2.15^{a}	57.7 ± 1.57^{a}
Wing	Guinea fowl	53.5 ± 2.10^{a}	55.4 ± 1.91	51.2 ± 1.65^{ab}	47.5 ± 1.86^{b}
	Chicken	44.0 ± 2.26^{a}	45.7 ± 2.03^{a}	42.2 ± 2.41^{a}	41.3 ± 1.49^{a}

[abc]Within trait and species, least square means with different superscripts differ ($P < 0.05$).

4.3.3 Abdominal fat and carcass remainders

Table 4.4 shows the least square means of abdominal fat and carcass remainders in female and male guinea fowls. The proportional weight of the abdominal fat was higher ($P < 0.05$) in adults at 24.5 ± 0.57 g/kg BW compared to 20.7 ± 0.62 g/kg BW in grower guinea fowl birds. Abdominal fat weight was significantly affected by sex whereby a value of 26.6 ± 0.74 g/kg BW in adult females was higher ($P < 0.05$) than 22.2 ± 0.84 g/kg BW in adult males (Table 4.4). Influence of age on carcass remainders was observed. Growing birds had higher ($P < 0.05$) weights than mature birds for the neck (42.4 ± 1.42 vs 34.3 ± 1.31 g/kg BW), head (39.5 ± 1.06 g/kg BW vs 28.0 ± 0.98 g/kg BW) and feet (36.7 ± 1.00 vs 25.0 ± 0.92 g/kg BW). The back weight increased with age as grower birds value (120.6 ± 6.52 g/kg BW) were lower ($P < 0.05$) than adults (148.7 ± 6.02 g/kg BW). Sex and the interaction age × sex had no significant effect on carcass remainders. Chickens accumulated more abdominal fat since adult chickens had higher ($P < 0.05$) values than growers (26.5 ± 0.74 g/kg BW and 22.2 ± 1.04 g/kg BW). Females had more ($P < 0.05$) abdominal fat weight than males (Table 4.4). Head weight in chickens decreased with age (Table 4.4).

4.3.4 Internal organs

Age had an effect ($P < 0.05$) on proportional weight of liver, kidney, heart, lung, and gizzard in guinea fowls (Table 4.5). All these variables showed a significant decrease with age. Liver weights in growers of 22.1 ± 0.75 g/kg BW were higher ($P < 0.05$) than in adults of 14.9 ± 0.69 g/kg BW).

Table 4.4: Effect of age and sex on abdominal fat and carcass remainder weights (g/kg BW) in scavenging birds

Trait	Species	Grower female	Grower male	Adult female	Adult male
Abdominal fat	Guinea fowl	21.0 ± 0.94^b	20.4 ± 0.85^b	26.6 ± 0.74^a	22.2 ± 0.84^a
	Chicken	24.2 ± 1.01^b	20.9 ± 0.91^c	29.6 ± 0.92^a	23.9 ± 0.67^b
Back	Guinea fowl	118.1 ± 7.30^b	120.2 ± 6.62^b	155.8 ± 5.77^a	147.3 ± 6.50^a
	Chicken	135.5 ± 7.86^a	128.5 ± 7.09^a	134.2 ± 7.12^a	137.9 ± 5.1^a
Neck	Guinea fowl	40.4 ± 2.33^a	45.7 ± 2.12^a	33.9 ± 1.91^b	31.9 ± 2.08^b
	Chicken	47.3 ± 2.52^a	52.8 ± 2.43^a	47.1 ± 2.28^a	50.6 ± 1.78^a
Head	Guinea fowl	39.0 ± 1.79^a	39.3 ± 1.62^a	26.3 ± 1.41^b	27.3 ± 1.59^b
	Chicken	51.7 ± 1.92^a	53.8 ± 1.74^a	38.7 ± 1.74^b	36.1 ± 1.27^b
Feet	Guinea fowl	34.2 ± 2.43^a	38.1 ± 2.20^a	24.0 ± 1.92^b	24.1 ± 2.16^b
	Chicken	53.7 ± 2.62^a	58.4 ± 2.36^a	41.1 ± 2.37^b	47.6 ± 1.73^b

^{abc}Within trait and species, least square means with different superscripts differ ($P < 0.05$).

Table 4.5: Effect of age and sex on internal organ weights (g/kg BW) of scavenging birds

Trait	Species	Grower female	Grower male	Adult female	Adult male
Liver	Guinea fowl	21.1 ± 1.65^{a}	22.8 ± 1.50^{a}	15.1 ± 1.34^{b}	4.1 ± 1.51^{b}
	Chicken	29.6 ± 1.78^{a}	28.5 ± 1.62^{a}	19.6 ± 1.61^{b}	20.3 ± 1.23^{b}
Kidney	Guinea fowl	7.8 ± 0.46^{a}	8.0 ± 0.44^{a}	5.9 ± 0.36^{b}	5.4 ± 0.41^{b}
	Chicken	11.5 ± 0.50^{a}	11.3 ± 0.45^{a}	7.5 ± 0.45^{b}	7.4 ± 0.33^{b}
Heart	Guinea fowl	6.1 ± 0.49^{b}	5.7 ± 0.36^{a}	5.2 ± 0.40^{c}	5.8 ± 0.45^{bc}
	Chicken	7.0 ± 0.54^{ab}	7.3 ± 0.49^{a}	7.0 ± 0.51^{ab}	8.4 ± 0.46^{b}
Lungs	Guinea fowl	8.8 ± 0.52^{a}	8.7 ± 0.38^{a}	6.2 ± 0.42^{b}	6.6 ± 0.48^{b}
	Chicken	11.9 ± 0.57^{a}	11.8 ± 0.52^{a}	8.5 ± 0.53^{b}	9.7 ± 0.49^{b}
Gizzard	Guinea fowl	51.4 ± 4.29^{ab}	38.8 ± 3.89^{a}	57.6 ± 3.39^{b}	56.1 ± 3.92^{b}
	Chicken	68.6 ± 4.63^{a}	75.3 ± 4.21^{ab}	79.1 ± 4.19^{c}	80.7 ± 3.06^{bc}
Spleen	Guinea fowl	0.90 ± 0.13^{a}	1.00 ± 0.12^{a}	1.05 ± 0.10^{a}	0.94 ± 0.12^{a}
	Chicken	0.95 ± 0.14^{a}	1.16 ± 0.12^{a}	0.94 ± 0.12^{a}	1.11 ± 0.09^{a}

^{abc}Within a trait and species,lest square means with different superscripts differ (P < 0.05).

The higher ($P < 0.05$) weights in growers than adults of kidney (8.7 ±0.41 vs 6.6 ±0.35 g/kg BW), heart (7.6 ±0.43 vs 6.1 ±0.40 g/kg BW), lung (9.4 ± 0.43 vs 6.4 ± 0.40 g/kg BW) and gizzard (32.9 ± 1.82 vs 26.3 ±1.69 g/kg BW) were observed. The spleen weight was affected by neither age nor sex of bird ($P > 0.05$). In chickens age had a significant effect on the liver, kidney and lung weights which were higher ($P < 0.05$) in growers than adults (Table 4.5). This follows the same trend as that reported for guinea fowls.

4.3.5 Weight and length of intestines

Relative intestine length of guinea fowl total intestines, small intestines and large intestines were significantly affected by age (Table 4.6). Total intestine length in growers (113.2 ± 4.15 cm/kg BW) was longer ($P < 0.05$) than in adults (74.3± 3.90 cm/kg BW). Growing birds had longer ($P < 0.05$) small intestines (89.7 ± 3.41 cm/kg BW) and large intestines (23.5 ± 1.20 cm/kg BW) than mature birds whose lengths were 57.0 ± 3.2 cm/kg BW and 17.3 ± 1.13 cm/kg BW for small intestines and large intestines respectively. No sex differences were observed ($P > 0.05$) on length of intestines. Age and sex had no significant effect on total intestinal weight. Intestinal weight and length in chickens were significantly affected by age. A decrease in total intestine weight from 64.7 ± 5.11 g/kg BW in growers to 47.5 ± 4.04 g/kg BW in adults was observed. Length of the total intestines, small intestines and large intestines decreased with age (Table 4.6).

Table 4.6: Effect of age and sex on weight (g/kg BW) and length (cm/kg BW) of intestines in scavenging birds

Trait	Species	Grower female	Grower male	Adult female	Adult male
Weight of intestine	Guinea fowl	48.3 ± 4.13^a	47.6 ± 4.12^a	45.7 ± 3.27^a	6.2 ± 3.69^a
	Chicken	74.5 ± 4.33^a	66.0 ± 4.10^a	46.6 ± 4.20^b	45.4 ± 3.03^b
Intestine length	Guinea fowl	112.5 ± 5.50^a	118.1 ± 4.96^a	70.2 ± 4.33^b	68.0 ± 5.28^b
	Chicken	139.7 ± 5.95^a	147.3 ± 5.39^a	95.5 ± 5.35^b	100.0 ± 3.91^b
SI length	Guinea fowl	89.4 ± 4.47^a	93.7 ± 4.03^a	53.2 ± 3.51^b	52.2 ± 4.29^b
	Chicken	112.4 ± 4.84^a	124.2 ± 4.38^a	81.3 ± 4.35^b	84.8 ± 3.18^b
LI length	Guinea fowl	23.1 ± 1.46^a	24.4 ± 1.31^a	17.1 ± 1.15^b	15.8 ± 1.40^b
	Chicken	27.3 ± 1.58^a	23.1 ± 1.43^b	14.3 ± 1.42^c	15.2 ± 1.04^c

^{abc}Within trait and species, least square means with different superscripts differ ($P < 0.05$).

SI - small intestine; LI - large intestine

4.4 Discussion

Body weights for guinea fowls were less than 1.4 ± 0.09 kg in guinea fowls observed by (Ogah, 2013) in Nigeria under semi-extensive system as well as 1 600, 1 717 and 1659 g of guinea fowls fed on diets with 3 000, 3100 and 3200 kcal of ME/kg as reported by Nahashon *et al*. (2005). These differences could be due to the lower plane of nutrition available in the scavenging guinea fowls.

Increase in body weight and carcass weight with age conforms to earlier findings in guinea fowls (Porwal *et al*., 2002; Nsoso *et al*. 2006; Fajemilehin, 2010; Kokoszynski *et al*., 2011b). Pedersen (2002) reported high body weights for mature male and female indigenous chickens in Zimbabwe. No differences in body weight and carcass traits observed between males and females in this study contradict earlier findings (Musa *et al*., 2006; Olawunmi *et al*., 2008). The similarity in body weight in both sexes observed could be due to the slow growth of the species which slows down the accumulation of weight. Weight of carcass components are influenced by weight at slaughter as conditioned by differences in climatic, managerial conditions of rearing, differences in genetic make-up as well as the statistical manipulation of the data used to obtain the estimates. Baeza *et al*. (2001) reported that sex effect on body weight is observed in almost all domesticated avian species where males are generally heavier than females which contradict with findings in this study. Lower weights for the leg, thigh and drumsticks in guinea fowl adults than in growing birds show allometric growth. Dissimilar growth patterns are shown by different body parts and traits (Alkan *et al*., 2011) as their growth rates vary (Koops and Grossman, 1991). Guinea fowls are faster flight birds which are also fast runners with a small skeletal frame. This may mean that they need lighter legs to enable these activities. The high breast weights in males than in females are similar to earlier reports on hybrids of Ross-308 and Lohmann Meat broilers (Marcu *et al*., 2013). On the contrary, Kokoszynski *et al*.

(2011b) reported higher breast weight in female than in males. Similarly, Merkley *et al*. (1980) reported that females had greater breast but smaller legs than males. Metabolic differences and the onset of fattening differences could explain these sex differences (Musa *et al*., 2006).

Guinea fowls are fast runners and this could explain their lighter feet than chickens. Swatland (1994) reported that there is extensive variation in poultry body proportions across breeds. Growing guinea fowls had a lower abdominal fat weight than mature birds which is similar to Blum and Leclercq (1977) who reported that the lowest abdominal fat content is observed in the lightest guinea fowls and Murawska *et al*. (2011) in Ross 308 broilers. Kokoszynski *et al*. (2011a) noted contradicting findings in game pheasants of decreasing abdominal fat content from18 weeks (0.2 ± 0.05 %) to 20 weeks (0.1 ±0.05 %) of age. Females had higher abdominal fat than males, also reported by Baeza *et al*. (2001). The latter authors observed that females had a higher percentage of abdominal fat in high growth rate and low growth rate lines of 3 % than males (2.2 %). A similar trend was reported by Kokoszynski *et al*. (2011a) in game pheasants and Kokoszynski *et al*. (2011b) in guinea fowls. Beg *et al*. (2016) reported that age and sex greatly influence fat as females deposited more fat than males and older birds had more fat than younger ones. A decrease in neck, feet and head with maturity is attributed to allometric growth of the birds. Similarly, Kaminska (1986) reported a decrease in the proportion of head and feet to body weight in broilers where a head content decrease was noted during the first seven days (from 13 to 9 % of body weight) and further decreased to 2.5 % total body weight at 12 weeks. Feet content in 2-day old chicks of 6 % decreased to around 4 % in 12 weeks old birds. Murawska *et al*. (2005) also reported a decrease in head content of broilers in the first six weeks from 6.9 to 2.3 %. Back weight increased with age similar to findings by Baffour-Awuah *et al*. (2000). The latter researcher observed longer bodies in females than in males in contrast to this study which found no sex differences on back weight. Similarly, Sogunle *et al*. (2006) observed an increased percentage back weight to body weight from 3 to 9 weeks old guinea fowls in Harco cockerels. Guinea fowls are characterised by long bodies reaching up to 59 cm as reported by Kozaczynski (1999). This could be as a result of isometric growth of the body part in poultry.

Decreases in relative weights of the liver, heart and gizzard and a constant spleen with age agree with Kokoszynski *et al*. (2011a) while they disagree on the heart which remained constant. The total inner edible organ (heart, liver and gizzard) weights expressed as percentages of cold-carcass weights in partridges were observed to decrease from 14 to 18 weeks of age (Yamak *et al*., 2016). Kasperska *et al*. (2012) observed that relative weights of the liver, heart and gizzard decrease with age. Janiszewska *et al*. (1998) found that among the internal organs which experience changes in growth at different rates, the highest age-related changes occur in the gizzard weight. The decreases in the internal organs reported showed allometric growth of the organs, relative to body weight.

Grower birds had longer lengths of intestines, small intestines and large intestines. This is similar to findings in broilers (Amerah and Ravindran, 2008) and game pheasants (Kokoszynski *et al*., 2011a) where relative small intestines length decreased with age. Mobini (2011) reported similar findings that, with increase in age, all the indices of relative values of intestinal parameters with relation to the Ross broilers' body weight decreased in both sexes.

With reference to chickens in the current study, guinea fowls had noticeably heavier carcasses than chickens which is supported by (CAB International, 1987) who reported that guinea fowls carcasses yield a large amount of meat due to their high meat to bone ratio. This suggests that guinea fowls can be adopted to complement chickens as a source of meat in households. In addition to high meat yield, guinea fowls accumulated less abdominal fat than chickens in this study since they are characterised by having lean meat,), which makes it appealing to health-conscious consumers Koney (1993).

4.5 Conclusions

The absolute body weight and relative hot carcass and cold dressed weights of mature guinea fowls were heavier than in growing birds. Meat cuts of leg, thigh and drumstick decreased in relative weight with the maturity of the birds. Males had higher breast weight than females. Abdominal fat weight increased with age with females fatter than males. Carcass remainders were heavier in growing birds than mature birds except for the back weight which increased with age. Growers had significantly higher weights of the heart, liver, kidney, lung and gizzard than adults. Relative total lengths of total intestines, small and large intestines were higher in growers than adults. This study could not fully establish the capacities in which the guinea fowls utilise the scavengeable feed resources.

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Chapter 5: Physicochemical properties of meat from scavenging helmeted guinea fowls in response to age and sex

Abstract

The effect of age and sex on body weight, carcass traits and physicochemical properties of breast muscle from helmeted guinea fowls managed under the scavenging system were assessed. A total of 48 scavenging helmeted guinea fowl growers (4 – 8 months old) and adults (one year old) and 48 chickens which were used as a benchmark with no statistical comparison between species. Body weight in adults was higher ($P < 0.05$) than in growers. Adult guinea fowls had higher ($P < 0.05$) absolute hot carcass weight (1067.8 ± 24.05 g), cold dressed weight (1038 ± 25.75 g) and breast weight (306.0 ± 9.35 g) than growers of 580.2 ± 26.04 g; 564.7 ± 27.88 g; 158.9 ± 10.13 g, for hot carcass, cold dressed and breast weight, respectively. Dressing percentage was higher ($P< 0.05$) in adult (69.3 ± 0.92 %) than grower (64.7 ± 1.00 g) birds. Males had heavier (245.4 ± 7.96 g) ($P < 0.05$) breasts than females (219.4 ± 9.26 g). Dry matter content decreased ($P < 0.05$) with age from 28.7 ± 0.81 % in growing birds to 24.7 ± 0.75 % in adults. In adult birds values of ether extract (1.3 ± 0.04 %) and ash (1.2 ± 0.04 %) were higher ($P < 0.05$) in growers of 0.8 ± 0.04 % and 0.9 ± 0.03 % for ether extract and ash, respectively. Females had more (1.3 ± 0.04 %) fat content than males (1.2 ± 0.04 %) ($P< 0.05$). Age and sex had no effect ($P > 0.05$) on crude protein. Increase in age resulted in darker ($L^* = 42.4 \pm 0.59$), redder ($a^* = 17.7 \pm 0.38$) and yellower ($b^*= 10.1 \pm 0.33$) meat than in younger birds of $L^* = 46.7 \pm 0.64$, $a^* =14.3 \pm 0.41$ and $b^* = 6.7 \pm 0.35$, respectively. Females breast muscles were yellower ($b^* = 9.0 \pm 0.32$) ($P < 0.05$) than males ($b^* = 7.9 \pm 0.28$). Shear force was higher ($P < 0.05$) in adults than growers. Cooking loss of 21.2 ± 0.42 %) in growers was higher ($P < 0.05$) than 16.4

± 0.39 % in adults. Females had higher ($P < 0.05$) cooking of 19.6 ±0.39 % than in males (18.0 ± 0.33 %).

Key words: breast muscle, carcass quality, muscle colour, meat quality, free range, guinea fowl, age

5.1 Introduction

Production of indigenous avian species are a means of livelihoods in Africa as most vulnerable smallholder farmers cannot afford to keep large livestock such as cattle, sheep and goats (FAO, 2004; Fakolade, 2015). These poultry are mainly kept extensively and scavenge for most or all of their feed. The indigenous poultry are kept mainly for meat and eggs for household consumption. They are characterised as slow-growing animals, realising a low carcass weight. Many of the smallholder farmers are introducing guinea fowl farming in synergy with the chickens to boost the production of protein, meat, eggs and income (Nahashon *et al*., 2006). The extent to which guinea fowls and chickens complement each other needs to be explored and exploited to improve food security of the resource-poor.

Guinea fowls (*Numida meleagris*) are classified as game birds (Little *et al*., 2000) whose meat is regarded to be tasty, gamey, flavourful, healthier and lean hence popular to the health conscious consumers (Bokkers and Koene, 2003; Tlhong, 2008). Guinea fowls consume a wide variety flora and fauna in their inhabitant of open savanna and savanna bush (Crowe, 1985) as compared to other domesticated avian species. They manage to provide the resource poor households with the much needed nutrients besides scavenging on poor quality resource base. Carcass traits and meat quality have been reported to be influenced by genotype (Ayorinde *et al*., 1988; Leterrier *et* *al*., 1999), age (Pudyszak *et al*., 2005; Mareko *et al.*, 2008; Kokoszynski et al., 2011) and sex (Leterrier *et al*., 1999; Baeza *et al*., 2001; Kokoszynski et al., 2011). There is paucity of data on the meat quality of scavenging poultry species including the under-utilised guinea fowls. In Chapter 3 guinea fowl rearing was popularised by their ability to supply meat and eggs to the communal households. The meat cuts of economic importance generally increased with age, with guinea fowls yielding more edible meat than the chickens they exist in synergy with (Chapter 4). The objective of the study was to assess age and sex effects on the body weight, carcass traits and, physicochemical composition of scavenging guinea fowl meat. It was hypothesised that meat from scavenging guinea fowls of different age and sex vary in their physicochemical properties.

5.2 Materials and Methods

5.2.1 Study site description

The study was conducted in Wedza District communal area located in Mashonaland East Province, Zimbabwe. Details are described in Section 3.1.

5.2.2 Sampling and slaughter of birds

Details on the sampling and slaughter of birds are given in section 4.2.2. The individual carcass for each bird was placed in separate labelled polythene bags, placed in a cooler box filled with ice and transported to the Animal Science Department Laboratory, University of Zimbabwe, for carcass and meat analyses.

5.2.3 Data collection

Measurements of the body weight (BW) and hot carcass were done using a mechanical top loading scale which weighs up to 5 kg in 20 g increments (Salter Model 250-6S). The carcass was weighed again after 24-hour refrigeration at 4 ºC to determine cold dressed weight. The breast of each bird was cut off the carcass and weighed before being deboned and stored in polyethylene bags at 4 °C for 24 h. *Pectoralis major* muscles were collected from the left side of the breast muscle and ground thoroughly for meat quality analyses after chilling the meat for 24 h. Dry matter, protein, intramuscular fat, ash, colour shear force, and cooking loss, were assessed on the *pectoralis major* muscle.

5.2.3.1 Proximate composition

The proximate composition of the breast samples was determined using procedures of the Association of Official Analytical Chemists (AOAC, 1990) on breast muscle tissues without tendons and fat. Moisture content was determined by drying at least 2 g of meat to a constant temperature at 105^{o}C in a drying oven overnight. Fat content was determined using the Soxhlet method with a solvent extraction system and protein content determined by the Kjeldahl method. Ash content was determined at 600 °C.

5.2.3.2 Meat colour

Meat colour for the breast muscle was measured using a computer vision system (Yam and Papadakis (2004). Fresh breast meat samples were obtained after 24 hour refrigeration. About 1.5 cm thick samples were individually placed on white polystyrene trays with a consistent colour. A digital camera (Canon EOS 1200D) was used to capture breast muscle images with 18 mega pixel resolution. The sample was placed inside a chamber with white non reflective surfaces which contained a camera and lighting system. The camera was placed vertically 20 cm away from the sample. The lighting system consisted of four 59 cm long fluorescent lamps (Osram L 18W/965 BIOLUX) with a colour temperature of 6500 ºK and a colour rendering index (Ra) close to 99. The lamps were placed 50 cm above the sample at an angle of 45º. The Adobe Photoshop CS3 software was employed for image analysis. The lightness (L*), redeness (a) and yellowness (b*) values were measured on the digital image of the sample visualised on the monitor by selecting an area of 0.5 x 0.5 inches. For each sample, four areas were used to calculate a mean value for L, a, and b. The L, a, and b obtained from the Histogram Window were converted to the standard L*, a*, b* values using the following formulas:

$$L* = \frac{Lightness}{255} \ x \ 100$$

$$a* = \frac{240a}{255} - 120$$

$$b* = \frac{240b}{255} - 120$$

The formulae are based on Yam and Papadakis (2004).

5.2.3.3 Water holding capacity

Water-holding capacity (WHC), in respect of cooking loss, was determined by placing meat samples after image capturing in thin-walled plastic bags and cooking in a continuously boiling water-bath for 50 minutes, with the bag opening extending above the water surface (Petracci and Baéza, 2009). Cooking loss was determined by the difference in weight between raw and cooked meat and expressed as a percentage.

5.2.3.4 Shear force determination

Shear force was determined on breast muscle strips which were obtained through cutting each muscle at the centre, parallel with the fibres. Raw meat pieces measuring 1.5 cm long x 1.5 cm wide x 0.5 cm thick were heated in plastic bags at 96 ºC for 10 minutes, in triplicate, for each sample. After heating they were left to cool to room temperature and cut to sizes of 1.0 cm long x 1.0 cm wide x 0.5 cm thick. Shear force for each strip was determined using a Warner-Bratzler shear device (G-R Electrical Mfg. Co., Manhattan, KS 66502; Model 5565, Instron Ltd., Buckinghamshire, UK). A cross-head speed of 200 mm/min and a 5 kN load cell calibrated to read over a range of 0-100 N were applied. The average value for the shear force (in pounds) required to shear the triplicate samples, was regarded as the shear value for the sample. The pound value recorded from the Warner-Bratzler shear device was converted to newtons (N) by multiplying by a factor of 4.4482216.

5.2.4 Statistical analyses

Analysis of variance was used to determine the effects of age and sex and their interactions on body weight, carcass traits and physicochemical properties of scavenging guinea fowl breast muscle meat using the PROC GLM procedure of SAS (2011). The model used was:

$$Y_{ijk} = \mu + A_i + S_j + (A \times S)_{ij} + \varepsilon_{ijk}$$

where:

Y_{ijk} = response variable (physical and chemical properties);

μ = overall mean common to all observations;

A_i = effect of the i^{th} age (i= grower, adult);

S_j = effect of j^{th} age (j = male, female);

$(A \times S)_{ij}$ = effect of interaction between i^{th} age and j^{th} sex;

ε_{ijkl} = random error with mean 0 and variance σ^2.

Least square means were calculated and separated using the LSMEANS and PDIFF procedure of SAS (2011).

5.3 Results

5.3.1 Slaughter weight and carcass traits

The significance levels for the effects of the variables on carcass and meat quality traits of scavenging chickens and guinea fowls are given in Table 5.1. There was a significant effect of age on weights of the birds at slaughter, hot carcass, cold dressed and breast, and dressing percentage (Table 5.1) in which adult guinea fowls had higher ($P < 0.05$) absolute values than growers (Table 5.2). Dressing percentage of 69.3 ± 0.92 % in adults was higher ($P < 0.05$) than 64.7 ± 1.00 g in grower birds. In growers, breast weight of 158. 2 ± 10.13 g was lower ($P < 0.05$) that 306 ± 9.35 g in adults. Males also had heavier ($P < 0.05$) breasts (254.4 ± 7.96 g) than females (219.4 ± 9.26 g). In adult chickens weights of slaughter, hot carcass, cold dressed and breast were higher ($P < 0.05$) than in growers (Table 5.2).

Table 5.1: Levels of significance for carcass and breast meat quality traits in scavenging chickens and helmeted guinea fowls

	Guinea fowls			Chickens		
	Age	**Sex**	**Age × Sex**	**Age**	**Sex**	**Age × Sex**
Slaughter weight/g	***	Ns	ns	***	ns	ns
Hot carcass weight/g	***	Ns	ns	***	ns	ns
Cold dressed weight/g	***	Ns	ns	***	ns	ns
Dressing percentage	**	Ns	ns	ns	*	*
Breast weight/g	***	*	ns	**	ns	ns
Dry matter/%	**	Ns	ns	ns	ns	ns
Crude protein/%	ns	Ns	ns	ns	ns	ns
Ether extracts/%	***	**	ns	***	*	ns
Ash/%	***	Ns	ns	*	ns	ns
L*	***	Ns	ns	**s	ns	ns
a*	***	Ns	ns	***	**	*
b*	***	*	ns	**	ns	ns
Shear force /N	***	Ns	ns	***	ns	ns
Water holding capacity/%						
Cooking loss/%	***	**	ns	***	**	ns

*P < 0.05; **P < 0.01; ***P < 0.001; ns – no significant difference (P > 0.05)

L* - lightness; a* - redness; b* - yellowness

Table 5.2: Effect of age and sex on carcass traits of scavenging birds

Trait	Species	Grower female	Grower male	Adult female	Adult male
Slaughter weight/g	Guinea fowl	913.8 ± 61.47^b	920.8 ± 55.71^b	1627.6 ± 48.58^a	1664.8 ± 54.76^a
	Chicken	878.8 ± 66.21^b	905.0 ± 59.72^b	1416.3 ± 59.99^a	1557.3 ± 43.84^b
Hot carcass weight/g	Guinea fowl	643.9 ± 45.88^b	581.7 ± 41.58^b	1113.1 ± 36.26^a	1164.1 ± 40.87^a
	Chicken	532.9 ± 49.42^b	586.3 ± 44.57^b	922.0 ± 44.78^a	1017.3 ± 32.72^a
Cold dressed weight/g	Guinea fowl	621.7 ± 47.18^b	568.8 ± 42.76^b	1069.8 ± 37.29^a	1141.2 ± 42.03^a
	Chicken	506.8 ± 50.82^b	569.0 ± 45.84^b	895.3 ± 46.04^a	999.2 ± 33.65^a
Dressing %	Guinea fowl	66.4 ± 1.32^b	64.1 ± 1.20^b	68.7 ± 1.05^a	70.2 ± 1.18^a
	Chicken	58.7 ± 1.43^b	64.5 ± 1.29^a	65.5 ± 1.29^a	65.2 ± 0.94^a
Breast weight (g)	Guinea fowl	161.2 ± 15.08^b	178.1 ± 13.72^b	321.8 ± 11.91^a	327.0 ± 13.42^a
	Chicken	105.9 ± 16.28^b	115.2 ± 14.63^b	185.7 ± 15.90^a	228.7 ± 10.78^a

^{abc}Within trait and species, least square means without a common superscript differ ($P < 0.05$).

Males had a higher ($P < 0.05$) dressing percentage of 64.9 ± 0.78 % than 61.5 ± 0.95 % in females. Female and male chickens did not differ ($P < 0.05$) in slaughter weight, hot carcass weight, cold dressed weight and dressing percentage. Weights observed in guinea fowls were generally of higher than in chickens.

5.3.2 Proximate composition of breast muscle

Age had a significant effect on dry matter, ether extract and ash content of the breast muscle meat (Table 5.1). With increase in age the dry matter content decreased with higher values ($P< 0.05$) observed in growers (28.7 ± 0.81 %) than in adults females (24.7 ± 0.75 %). Mature birds had higher ($P < 0.05$) values for ether extract (1.3 ± 0.04 %) and ash (1.2 ± 0.04 %) compared to values in growers of 0.8 ± 0.04 % and 0.9 ± 0.03 %, respectively. Age had no effect ($P > 0.05$) on crude protein. Sex had an effect ($P < 0.05$) on ether extract where higher content ($P< 0.05$) in females (1.1 ± 0.04 %) than in males (1.0 ± 0.03 %). No effect ($P > 0.05$) of sex on dry matter, crude protein and ash content were observed (Table 5.3). Observations on ether extract content in chickens showed that growers had lower content ($P < 0.05$) of 1.0 ± 0.06 % than 1.5 ± 0.04 % in adults. Ash content was higher ($P < 0.05$) in adults (1.2 ± 0.04 %) than growers (1.0 ± 0.05 %). Chicken breast meat recorded higher ether extract content and lower protein content values than guinea fowl meat.

5.3.3 Colour, cooking loss and shear force of breast muscle

Effect of age was significant on guinea fowl meat colour parameters of lightness (L*), redness (a*) and, yellowness (b*), shear force and cooking loss (Table 5.4). Adult birds had lower (P <

Table 5.3: Effect of age and sex on proximate composition of scavenging from scavenging birds

Trait (%)	Species	Grower female	Grower male	Adult female	Adult male
Dry matter	Guinea fowl	28.1 ± 1.06^{ab}	28.4 ± 0.96^{a}	24.1 ± 0.83^{b}	23.9 ± 0.94^{b}
	Chicken	24.4 ± 1.14^{a}	25.9 ± 1.03^{a}	24.1 ± 1.03^{a}	23.3 ± 0.75^{a}
Crude protein	Guinea fowl	22.8 ± 1.17^{b}	24.6 ± 1.06^{ab}	27.4 ± 0.92^{a}	27.5 ± 1.04^{a}
	Chicken	20.8 ± 1.26^{ab}	18.6 ± 1.14^{b}	24.7 ± 1.14^{a}	24.5 ± 0.83^{a}
Ether extract	Guinea fowl	0.9 ± 0.06^{b}	0.8 ± 0.06^{b}	1.3 ± 0.05^{a}	1.2 ± 0.06^{a}
	Chicken	1.1 ± 0.07^{bc}	1.0 ± 0.06^{c}	1.6 ± 0.06^{a}	1.3 ± 0.04^{b}
Ash	Guinea fowl	0.9 ± 0.04^{b}	0.9 ± 0.04^{b}	1.2 ± 0.03^{a}	1.2 ± 0.04^{a}
	Chicken	1.0 ± 0.05^{b}	1.0 ± 0.04^{b}	1.2 ± 0.04^{a}	1.2 ± 0.03^{a}

^{abc}Within trait and species, least square means without a common superscript differ ($P < 0.05$).

Table 5.4: Effect of age and sex on colour (L*, a*, b*), shear force and cooking loss of breast meat from scavenging birds

Trait	Species	Grower female	Grower male	Adult female	Adult male
L*	Guinea fowl	46.9 ± 0.74^{a}	47.4 ± 0.67^{a}	43.5 ± 0.58^{b}	41.3 ± 0.66^{b}
	Chicken	48.2 ± 0.79^{ab}	48.5 ± 0.71^{a}	45.8 ± 0.2^{bc}	44.7 ± 0.52^{c}
a*	Guinea fowl	14.8 ± 0.44^{b}	14.0 ± 0.40^{b}	17.2 ± 0.35^{a}	18.6 ± 0.40^{a}
	Chicken	11.9 ± 0.48^{b}	11.8 ± 0.43^{b}	14.3 ± 0.43^{a}	15.8 ± 0.32^{a}
b*	Guinea fowl	7.1 ± 0.53^{b}	5.8 ± 0.48^{b}	10.7 ± 0.42^{a}	9.3 ± 0.47^{a}
	Chicken	7.7 ± 0.57^{b}	8.0 ± 0.51^{b}	12.3 ± 0.51^{a}	10.2 ± 0.38^{a}
Shear force /N	Guinea fowl	2.7 ± 0.51^{b}	2.4 ± 0.46^{b}	7.4 ± 0.40^{a}	7.9 ± 0.45^{a}
	Chicken	3.4 ± 0.55^{b}	3.2 ± 0.49^{b}	7.1 ± 0.49^{a}	7.4 ± 0.36^{a}
Cooking loss/%	Guinea fowl	21.8 ± 0.58^{a}	20.9 ± 0.52^{a}	17.7 ± 0.46^{a}	15.0 ± 0.51^{b}
	Chicken	20.2 ± 0.62^{a}	19.3 ± 0.56^{a}	16.2 ± 0.56^{b}	14.0 ± 0.41^{b}

^{abc}Within trait and species, least square means without a common superscript differ ($P < 0.05$)

L* - lightness; a* - redness; b* - yellowness

0.05) values for lightness ($L^* = 42.4 \pm 0.59$) and, higher ($P < 0.05$) for redness ($a^* = 17.7 \pm 0.38$) and yellowness ($b^* = 10.1 \pm 0.33$) than growers of $L^* = 46.7 \pm 0.64$, $a^* = 14.3 \pm 0.41$ and $b^* = 6.7 \pm 0.35$, respectively. Yellowness between sexes showed that female breast muscles (9.0 ± 0.32) were yellower ($P < 0.05$) than in males (7.9 ± 0.28). Shear force in adult females (7.4 ± 0.40 N) and males (7.9 ±0.45 N) was higher ($P < 0.05$) than in grower females (2.7 ± 0.51 N) and males (2.4 ±0.46 N) (Table 5.4). Cooking loss was higher ($P < 0.05$) in growers (21.2 ± 0.42 %) than adults (16.4 ± 0.39 %). Sex affected cooking loss where more loss ($P < 0.05$) was in females (19.6 ±0.39 %) than in males (18.0 ± 0.33 %). Chicken breast muscle was affected by age on colour (L*, a*, b), shear force and cooking loss (Table 5.4). Lightness value was higher ($P< 0.05$) in growers ($L^* = 48.5 \pm 0.71$) than in adults (44.8 ± 0.51). Adult breast muscles were redder ($P< 0.05$) ($a^* = 15.02 \pm 0.24$) and yellower ($P < 0.05$) ($b^* = 11.1 \pm 0.49$) than in growers ($a^*= 11.8 \pm 0.33$; $b^* = 7.9 \pm 0.68$). Shear force increased with age whilst cooking loss decreased ($P < 0.05$) (Table 5.4). With reference to chickens used in this study, guinea fow meat was darker, redder and less yellow. In addition, shear force values were greater than adult guinea fowls than adult chickens.

5.4 Discussion

Differences were observed on the physical and chemical properties guinea fowls breast muscle investigated of different age and sex. The cold dressed weight was observed to be lower than the hot carcass weight due to the water loss from the carcass which occurs during the refrigeration period. Higher weight for body weight, carcass traits and dressing percentage in adults than grower birds conforms to findings by Kokosyzinski *et al.* (2011) in 13 week and 16 weeks old guinea fowls. Growth is contributed by an increase in carcass muscle content (Yamak *et al.*, 2016). However, the research by Kokoszynski *et al*. (2011) reported lower slaughter weights of 1377 ± 1.60 g in males and 1350 ± 3.0 g as compared to this study. Laudadio *et al.* (2012) reported much higher body weights of 1969 ± 34.57 g and 1981 ± 34.57 g in 12 week old guinea fowl broilers fed soybean and peas, respectively. These differences in body weight are brought about by differences in age, rearing system, diet composition and strain. Dressing percentage in this study is lower than 75.4 % and 71.6 % in guinea fowls reared under the intensive and semi-extensive systems, respectively (Saina, 2005). The average dressing percentage of above 73 % for poultry reported by Muth *et al*. (2006) is higher than the proportions found in this study. Guinea fowls showed that they can substitute the traditional chickens as a meat source especially in the resource poor communities.

With increase in age dry matter content decreased similar to findings in indigenous Venda chickens (Raphulu *et al*., 2015) and broilers (Fanatico *et al*., 2005). The dry matter content in this study was within the range found in guinea fowl broilers of 27 % (Laudadio *et al*., 2012) and guinea fowls of 26 % (Tlhong, 2008). Sex did not influence dry matter similar to findings by Raphulu *et al*. (2015) and contradicts with Lukaszewicz and Kowalczyk (2014) where females had higher DM values than male broilers.

Fat content increased with age, a similar finding by Castellini *et al.* (2002) and Raphulu *et al.* (2015). The former found that as birds mature there is accumulation of more fat. Aberle *et al*. (2001) noted that normally, when an animal ages there are changes in the body and muscle composition; increase in protein and fat content and a decrease in moisture although an increase in breast meat moisture content was observed in this study. The fat content observed in this study are lower that reported in Standard (2.8 %) and Label (2.4 %) guinea fowl broilers (Baeza *et al*., 2001). Laudadio et al. (2012) reported fat content of 1.85 % and 2.17 % in guinea fowl broilers. A higher fat content in females is attributed by the ability of females to accumulate abdominal fat than males as observed in the current study. Similar finding were reported in earlier studies (Baeza *et al*., 2001; Kokoszynski *et al*., 2011). Values observed in chickens indicate that guinea fowls are leaner hence suitable for health-conscious consumers.

Ash content increased with age similar to findings by Fakolade (2015) in chickens and quails where ash content of breast and thigh meat increased from 4 weeks to 20 weeks of age. A similar trend was noted by other previous studies (Diaz *et al*., 2010; Raphulu *et al*., 2015). An increase in mineral content results in the rise in ash content. On the contrary to these study findings, Grey *et al*. (1983) observed a decrease in ash content in a commercial British broiler strain (Ross 1). Ash content values are within the range reported by previous research findings (Tlhong, 2008; Tejerina *et al*., 2009; Laudadio *et al*., 2012). Hoffman and Tlhong (2012) reported ash content values above 1.3 % in guinea fowls, higher than reported in this current study. Factors such as slaughter age, nutrition and production system contribute to these variations.

The protein content for guinea fowl breast meat in this study is above its average value of 23 % and 19 % for a typical mammalian muscle as reported by CAB International (1987). A lower protein content value of 22 to 23 % in guinea fowls was reported in earlier studies (Tlhong, 2008; Laudadio *et al.*, 2012). The observed CP content of guinea fowl meat contained more protein than the chickens used as a reference in this study. This is supported by CAB International (1987) who noted that guinea fowl meat contains more protein than other poultry species. This proves that guinea fowls can be an alternative to traditional chickens as a protein source. No sex differences in protein content are similar to findings by Souza *et al*. (2011).

Meat colour is one of the important characteristics of meat noted by consumers which defines meat quality. Meat quality can be affected by various factors such as age, sex, genotype, nutrition, meat moisture content, intramuscular fat, pre-slaughter conditions and processing variables (Yang and Jiang, 2005). Lightness values reported for guinea fowls are lower than 46.0 to 50.7 reported by Kokoszynski *et al*. (2011) and higher than 52 by Chiericato *et al*. (2001). Higher values of 42.3 ± 5.01 and 38.8 ± 1.46 were observed by Wattanachant *et al*. (2004) in pectoral major muscles of Thai indigenous and broiler chickens, respectively. The L* values found in this study for lightness are considered to in the normal range and not too pale (Woelfel *et al*., 2002). The differences in the L* values recorded could be due to the methods used for colour estimation as compared to the current study.

Higher yellowness in adult guinea fowl is due to the more fat content of the breast muscle than guinea fowls observed in the present study. With increase in age there was a decrease in lightness due to thicker fillets in older and heavier birds which results in a darker colour, similar to Fanatico *et al*. (2005) in slow-growing broiler genotypes. Redness increased with age due to an increase in the myoglobin levels as reported by Gordon and Charles (2002). Baeza *et al*. (2001) highlighted that haeme pigmentation increases with age. A higher yellowness in adults birds than growers is conforms to Fanatico *et al*. (2005) who reported yellower carcasses in foraging broilers than in indoor reared broilers. Increased time of access to forage by the guinea fowls results in yellower flesh of the breast as birds ingest more pigments from plants. Female breast meat was more yellow than males similar to findings by Souza *et al*. (2011) where male broilers had lower yellowness values as compared to females. The higher amount of accumulated fat in females than males contributes to the more yellow colour of meats (Havenstein *et al*., 2003; Fanatico *et al*., 2005). Female and male breast meat did not differ in lightness and redness similar to findings by Souza *et al*. (2011) in three broiler strains. Animal related factors generally influence meat colour namely, the genotype as the main factor (Fletcher, 1995) and the age of the animals (Gordon and Charles, 2002). Guinea fowl meat was darker, redder and less yellow than chicken meat in the study. The chicken meat in this study is regarded as dark meat ($L^* < 47$) according to an instrumental L^* values scale given by Totosaus *et al*. (2007).

The values for shear force increased with age similar to findings by Diaz *et al*. (2010) between in capon breeds (Mos, Sasso T-44 and Sasso X-44) and in broilers by Poltowicz and Doktor (2012). The increase in shear force is caused by the increase in hardiness of the connective tissue with aging as the collagen cross-linkages toughen (Fletcher, 2002; Diaz *et al*., 2010). The shear force values for the guinea fowls were lower than those from previous studies for broilers (Fanatico *et al*., 2005; Souza *et al*., 2011; Li *et al*., 2016) and indigenous Naked neck and Ovambo chickens (Chikumba *et al*., 2014), probably due to differences in cooking methods and apparatus used for measurement.

Growers had a higher cooking loss value than adult birds which is contrary to findings by Dunn *et al*. (1993) where the effect due to age showed cooking loss increasing with age in 60 day old free range and 44 day old standard broilers. These differences could be due to the early slaughter age used as compared to this study. Females had higher cooking loss than males due to the high fat content in females reported in this study. During cooking there is a proportion on the intramuscular fat that is lost and these contribute to fluids lost. The cooking loss values obtained in this study are lower than those reported in previous studies (Fanatico *et al*., 2007; Chikumba *et al.*, 2014) and higher than those observed in guinea fowls by Dahouda *et al*. (2009). These differences could be caused by variations in cooking temperature and duration or poultry species or ultimate pH or muscle used.

5.5 Conclusions

Slaughter weight, hot carcass weight, cold dressed weight, breast weight and dressing percentage in guinea fowls increased with age. Heavier breasts were found in males than in females. Dry matter content was higher in growers whilst fat and ash content were higher in adult birds. With increase in age breast meat colour became darker, redder and yellower whilst shear force increased and cooking loss decreased. Meat of females had higher values for yellowness (b*) and cooking loss than males.

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Chapter 6: General discussion, conclusions and recommendations

6.1 General discussion

Village poultry in Sub –Saharan Africa plays a vital role in the resource poor communities and are kept in almost every household. They are a source of livelihood for rural households (FAO, 2002; Ali *et al*., 2011) as they provide protein and income. Indigenous poultry are appropriate for the smallholder farmers as they make use of the locally available resources (Sonaiya *et al*., 1999). Even though they are raised under fewer inputs, they still provide the households with meat, eggs and income through sale of their products (Muchadeyi, 2007). Deficiency in animal protein sources in developing countries remains an issue of concern especially in the rural communities (Obike *et al*., 2011). This validates the need to investigate other underutilised poultry species that contribute to the increase in animal protein besides chickens which represent the main poultry species kept and is characterised by small body frames which yield low carcass weight (Missohou *et al*., 2002; FAO, 2004). Guinea fowls are native to Africa, hence a possible option for smallholder farmers. Their production is done mainly on free range where they scavenge for food with minimal management and inputs requirement especially in terms of housing, nutrition and medication. With this contribution in households, they are invisible on wealth ranking where cattle, goats and sheep are considered more important.

Helmeted guinea fowls are kept in small numbers together with the traditional chicken by smallholder farmers as a protein source (Adjetey, 2006) showing that it is an emerging species. Guinea fowl meat is leaner, gamey flavoured and highly priced as compared to chicken meat (Koney, 1993) which is preferred by health-conscious consumers. Promoting the underutilised guinea fowls is impossible without knowledge of their meat yield and quality. The study, therefore, sort to understand the management practices and production systems in which the guinea fowls are reared and determine carcass traits and meat quality in synergy with indigenous chickens.

The hypothesis tested in Chapter 3 was that there is a variation on the management practices employed by communal farmers and possible opportunities and constraints in guinea fowl production was tested. A relatively young age group (26 to 40 years) of guinea fowls keepers observed showed that these are the people who are active in farming activities in households who derive livelihoods from guinea fowls (Teye and Adam, 1999). Women dominated men in ownership of guinea fowls similar to findings by Moreki et al. (2010). This is a common finding in previous studies involving village poultry (McAinsh *et al*., 2004; Muchadeyi *et al.*, 2007). Small livestock species are suitable to be kept by women who have limited resources and are generally unemployed (Gueye, 2003; Moreki and Seabo, 2012). Guinea fowls are therefore, a source of livelihood for the women as they take major roles in the management and marketing of the birds and eggs (Saina *et al*., 2005). Women would benefit from guinea fowl production as they belong to the disadvantaged groups in communal areas.

There was greater reliance on agricultural activities mainly crop production for income sources by the farmers similar to findings in earlier studies (Gueye, 2002; Muchadeyi *et al*., 2004; Muchadeyi *et al*., 2007).This contributes to the conservation of the animal genetic resources as farmers derive livelihood from them (Geerlings *et al*., 2002; Anderson, 2003). Communal farmers have limited resources which they need to share among their several farming activities. Supporting of animal genetic resource for incomes is hindered by their low productivity influenced by climatic conditions and poor management which makes them susceptible to diseases and pests which results in high mortalities.

Guinea fowls were kept under the scavenging production system which is a low input/output system (Saina *et al*., 2005). Farmers keep them in small numbers in as they cannot afford inputs to direct to livestock production. Guinea fowls were kept together with chickens as they both required the same management practices. Minimal attention was given to the birds as guinea fowls production was considered as a sideline enterprise ranked after cattle, goats and chickens. However, chicken were used as guinea fowl egg incubators since guinea fowls they are poor mothers (Moreki, 2009). This helps in improving hatchability through reduction in egg wastages. Guinea fowls are hardier than chickens a characteristic which suits its production under harsh climatic conditions and poor management with the ability to provide households with meat, eggs and income. Meat and eggs were the major uses of guinea fowls as reported by Saina *et al*. (2005), which is a role also played by chickens.

Generally, no artificial selection practices were employed, which could partly explain the low egg production and hatchability under the free range system. Production was also hindered by lack of adequate supplementation, predation and lack of capital.

In chapter 4, it was hypothesised that carcass and internal organ weights varied with sex and age of scavenging guinea fowls. Guinea fowls had lower body weight as compared earlier study findings of greater than 1.4 kg (Nahashon *et al*., 2005; Ogah, 2013). This difference could be attributed to the lower plane of nutrition available in the scavenging guinea fowls as compared to intensively reared flocks.

Mature birds were heavier in body and carcass weight similar to findings by in guinea fowls by Nsoso *et al*. (2006) and Fajemilehin (2010). Accumulation of muscle with age represents growth in animals. No sex differences in body weight observed are contrary to earlier findings (Baeza *et al*., 2001; Kokoszynski *et al*., 2011) could be due to the slow growth of the nature of the poultry. Allometric growth was observed in the weights for the leg, thigh and drumsticks in guinea fowl adults which were lower than in growers. The different body parts had dissimilar growth patterns as their growth rates vary (Koops and Grossman, 1991; Alkan *et al*., 2011). Males had heavier breast weights than in females, similar to earlier findings in broilers (Marcu *et al*., 2013). Metabolic and the onset of fattening differences could explain these sex differences (Musa *et al*., 2006). Mature guinea fowls had more abdominal fat weight than growing birds whilst females were fatter than males. Age and sex were reported to influence abdominal fat in similar findings by Kokoszynski *et al*. (2011) and Beg *et al*. (2016). A decrease in neck, feet and head with maturity was attributed to allometric growth of the birds as reported in earlier studies (Kaminska (1986; Murawska *et al*., 2005). Isometric growth of the back was observed as its weight increased with maturity. Relative weights of the liver, heart, lungs and gizzards conforms to earlier studies (Janiszewska *et al*., 1998; Kasperska *et al*., 2012) which attributed the decrease due to allometric growth of the internal organs. A similar decreasing trend with maturity of birds was observed for intestinal lengths in the current study.

The hypothesis tested in Chapter 5 was that, there was a variation in the physicochemical properties of meat from scavenging guinea fowls of different sex and age. Guinea fowls increased carcass muscle content with age showing growth with age (Yamak *et al.*, 2016). Dressing percentage was lower than 70.1 to 75.4 % as reported in earlier studies (Saina, 2005; Kokoszynski *et al*., 2011). Dry matter content was within the range of 29 to 27 % reported in guinea fowls (Tlhong, 2008; Laudadio *et al*., 2012) and it decreased with age. Fat content increased with age similar to findings by Kokoszynski *et al*. (2011). Older birds accumulate more fat than younger birds (Raphulu *et al*., (2015). An increase in ash content was evident of increase in mineral content with longer exposure to forage as birds scavenge for food. Protein content for guinea fowl breast meat in this study was above 23 % which is regarded as the species average and 19 % for a typical mammalian muscle as reported by CAB International (1987). A decrease in meat colour lightness with age was attributed to thicker fillets in older and heavier birds which results in a darker colour, similar to findings by Fanatico *et al*. (2005) in slow-growing broiler genotypes. Increase in heme pigmentation with age caused redder meat in adult guinea fowls than growers as noted by Baeza *et al*. (2001). Yellower meat in adults bird observed was evident of more exposure time to pigments from plants which scavenging birds ingest (Fanatico *et al*., 2005). Females had yellower meat due to their higher fat content than males observed in this study. Shear force was higher in adult guinea fowls than growers due to an increase in hardiness of the connective tissue with aging as the collagen cross-linkages toughen (Fletcher, 2002; Diaz *et al*., 2010). The toughening of collagen cross-linkages could have resulted in the lower cooking values in older birds. Females had a higher cooking loss than males due to the higher fat content observed, which is lost as fluids during cooking.

The benchmark used of chickens in this study showed differences with guinea fowls. As compared to the benchmark, guinea fowls had heavier body weight and carcass traits which yielded more meat. Guinea fowls were leaner than chickens as noted (CAB International, 1987); Koney, 1993) hence suitable for health-conscious consumers. Crude protein content was aslo higher in guinea fowls compared to the standard. Meat colour of guinea fowls was darker, redder and less yellow than the benchmark. Guinea fowls showed that they be adoped as an alternative to traditional chickens as a meat source especially in the resource-limited communities.

6.2 Conclusions

Guinea fowls production management practices varied among farmers and constraints included predation, feed shortages and inadequate capital. The latter hindered the provision of optimal protection, nutrition and medication for the birds. Although guinea fowls were kept under sub-optimal conditions they provided meat. Increase in age of guinea fowls resulted in higher meat yield of prime cuts while internal organs decreased relative to body weight. Physicochemical properties of the meat varied with age and, sex with older birds meat observed as darker, redder and yellower. Guinea fowls produce lean meat which is protein rich. It was concluded that guinea fowls can be adopted as an alternative protein source to traditional chickens.

6.3 Recommendations

Village poultry are commended to be hardy and contribute to livelihoods of poor resource communities. The underutilised guinea fowls, whose production is in its infancy need to be promoted. Management practices performed by rural farmers need to be improved so as to increase the birds' productivity. Proper housing facilities, supplementation, watering and health care are essential to reduce mortalities and loss due to predation, pests and diseases. The ability of the birds to free range means that they feed on a low plane of nutrition. Farmers take advantage of this characteristic, hence; see no need for any supplementation since the birds are able to provide meat and eggs.

Aspects on providing nutrition through growing locally available forages, harvesting and processing will help in the intensification of village poultry production. Awareness can also be raised on the need to separate poultry species such as chickens and guinea fowls to prevent disease spreads.

Areas that need further research include:

1. Determining flock dynamics, use patterns and factors that affect efficient production of guinea fowls in communal areas;
2. Assessing seasonal changes in the feeding behaviour of guinea fowls
3. Determining the effect of season on nutritional quality and amino acid composition of the identified feeds consumed by scavenging guinea fowls
4. Determining guinea fowl meat consumption patterns among rural households
5. Conducting on-farm trials to determine the contribution and quality eggs from rural households
6. Determination of sensory attributes and of free range guinea fowl meat
7. Assessing the nutrient contents of the feed materials that scavenging guinea fowls scavenge
8. Determining the optimum protein and energy ratios and levels on growth performance, carcass composition and meat quality of guinea fowls

9. Determining the age at which guinea fowls reach slaughter age under extensive management system
10. Assessing farmer perceptions on the use of non-conventional animal protein sources for scavenging guinea fowls
11. Conducting economic evaluations of guinea fowl production and marketing under free range system

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Appendices

Appendix 1: Questionnaire administered to smallholder farmers to give an understanding of the production systems, management practices employed and, possible opportunities and constraints in Wedza district communal area

Enumerator... **Questionnaire number**...............

Date of interview........./........../........

A. Household demographics

1. Name of farmer...
2. Village..........................3.Ward..........4.District..........................5.Ecozone.....................
6. Sex of interviewed farmer (1=male; 2=female)......... 7.Tribe...................................
8. Marital status

1.Married		2.Widowed		3.Divorced		4.Single	

9. Household head (1=male; 2=female)...........
10. Age of household head

≤ 25yrs		26 – 40yrs		41 – 55yrs		56 – 70yrs		>70yrs	

11. Household size 1.Adult males....... 2. Adult females..... 3. Children (<15 years)........

B. Livestock and crop activities

1. Land holding/farm size

Crops	
Grazing*	
Forest	

Total

*other than communal

2. Source of income (*Tick first column as appropriate and in the second column rank importance where *1 = most important*)

	Tick	***Rank**
1. Crops		
2. Livestock		
3. Home industries		
4. Salary/ wages		
5. Remittances		

3. Livestock species kept and crops grown (**1 = most important*)

Livestock	No. of animals	Rank*
1.Cattle		
2. Goats		
3.Sheeep		
4. Chickens		
5. Pigs		
6. Guinea fowls		

Crops	Area (ha)	Rank*
1.Maize		
2. Cotton		
3.Soyabean		
4. Tobacco		
5.Small grains		
6.Groundnuts		

7.Other (specify)				6.Other (specify)		

C. Guinea fowl production

1. Guinea fowl flock size

Guinea fowl class	Number
1. Keets	
2. Growing hens	
3. Growing cockerels	
4. Mature hens	
5. Mature cockerels	

2. What are the reasons for keeping guinea fowls?..

   ....

   ....

3. What is the importance of keeping guinea fowls?

Importance of guinea fowl production	**Tick relevant**
Chickens are becoming less relevant	
Both chickens and guinea fowls increase production	
Other	

4. Which production system do you keep the guinea fowls under?

Intensive		Semi-intensive		Extensive	

5. Which type of guinea fowls do you keep?

Pearl		White		Lavender		Splashed or pied		White breasted	

6. Guinea fowl rearing experience (years)

0 – 2		3 – 5		6 – 9		>10	

7. Who owns the guinea fowls?

1.Husband		2.Wife		3.Son(s)		4.Daughter(s)		5.Other – who?	

6. Who is responsible for management and marketing of guinea fowls?

Task	Who is responsible?			
	Adults		Children	
	male	female	boy	girl
1. Management				
2. Marketing				

7. Do you separate other poultry species from where you keep guinea fowls during the day or at night?

Day...

Night...

8. Do you keep different age groups of guinea fowls in different compartments?

   Yes(1)....../No(2)......

9. At what age do your guinea fowl hens start laying?.......................................

10. Where does the guinea hens lay their eggs?..

11. How often do you collect the eggs for incubation?..

12. How many clutches per year?.............................

13. How do you incubate the eggs?

Use guinea fowl hens		Use chicken hens		Other (specify)......................	

14. How many chicks on average survive the first two months?.................................

15. Are you satisfied with the level of production of your guinea fowls?

    Yes (1).... / No(2)....

16. Why?...

17. Do you swap chicken eggs for guinea fowl eggs? Yes(1).... / No(2)....

18. In what ways do chickens assist in guinea fowl trade?

Selling chickens to buy guinea fowls		Barter trading chickens for guinea fowls		Other (specify)	

D. Breeding practices

1. Do you select birds for breeding purposes? Yes (1).... / No (2)....

2. If No in (D2) state reason(s)

Lack of knowledge		No breeding stock from other flocks	
Small stock in the household		Other, specify.....................................	

3. Which traits do you select for?

Trait	**Rank***
Body weight	
Body frame	
Meat taste/quality	
Egg number	
Egg size	
Survivability	
Disease tolerance	
Drought tolerance	
Heat tolerance	
Mothering ability	
Other	

**1 = Most important*

4. How do you ensure that guinea fowls behave like chickens?

Killing the wild guinea fowl after laying eggs		Killing the wild guinea fowl after eggs have hatched	
Chickens raise the keets after hatching		Other (specify)...............................	

E. Guinea fowl uses

1. How do you rank the function of guinea fowl in the household? (**1 = Most important*)

Function	*Rank

Source of food	
Source of income	
Social functions (ceremonies, gifts, etc.)	
Other (specify)...	

2. How many eggs did you consume in a month?

None		1 – 5		5-10		10 – 20		More than 20	

3. In the case of incubation, how many did you incubate last month?...........

4. Of the incubated eggs, how many were;

Wasted	
Hatched	
Stolen/ Eaten by other creatures	
Other (specify)..	

F. Marketing

1. Marketing type

Formal		Informal	

2. How much do you receive?

	Keets	Growers	Hens	Cockerels	Eggs
Quantity					
Unit Price					

Total income					
Buyer					

3. What is the average price per guinea fowl bird?

Cockerels.......................................Hens..Keets.................................

4. What is the price per chicken?...

5. How many guinea fowls have you sold in the past two months?...................................

6. What is the average price for each egg?...

7. When and why do you sell your guinea fowl and eggs?...

   ....

G. Health

1. What are the main causes of guinea fowl mortality?(**1=Main cause)*

Mortality cause	Tick	*Rank	Mortality cause	Tick	*Rank
Birds of prey			Cats and dogs		
Wild mammals			Theft		
Accidents			Lack of feed		
Diseases					

2. What common diseases affect guinea fowls?..

....

3. How many of your birds have died in the last six months?

	From disease		Slaughter		Other causes	
	Keets	Adults	Keets	Adults	Keets	Adults
Guinea fowl						

Chickens			
Other - what?			

4. What treatment do you give your sick birds?

	Conventional	Traditional
Treatment		

5. Where do you get the treatment?

Source	Do you pay? Yes	No	If yes, how much?
Veterinary Services			
Traditional			
Pharmacy NGO/Project			
Shop/market			
Other – where			

6. Do you vaccinate your guinea fowl against any disease? Yes(1)...... / No(2)......

7. If yes, what disease(s) were the birds vaccinated against?..

   ....

H. Nutrition

1. What type of feed do you give to your guinea fowls?

Type of feed	**Ground**	**Whole**	**Frequency of feeding**	**Time of year available**
Nothing				

Maize				
Sunflower				
Groundnuts				
Sorghum				
Maize bran				
Food scraps - what?				

2. What is the source and storage of the feeding material?

Source	Purchased	Good material	Waste material	Storage
Own previous year's harvest				
Market place				
Grinding mill				
Other....................................				

3. How are the feeds presented to the guinea fowls?

In a bowl		Thrown on ground		Other (specify)................................	

4. Do you mix the feed for the birds?

   ....

5. If yes, how do you mix it?...

6. How much feed do you give the guinea fowls per day?..

7. Do you offer the same feed to chickens? Yes (1)...... / No(2)......

8. If no, how does their feeding differ with guinea fowls (type and quantities)?

   ....

9. Rank guinea fowls in terms of ease of feeding and ability to survive during droughts

   (*Rank *1 = Easier to feed; Hardier*)

	Feeding	Hardiness
Guinea fowls		
Chickens		

10. Do you give guinea fowls supplementary feed? Yes(1)...... / No(2)......

11. If yes, how frequent do you provide the supplementary feed?

Twice per day or more	
Once per day	
Four times per week or more	
Four times per two weeks or less	

12. What is the source of the supplementary feed?...

13. Do you give water to your birds? Yes (1)...... / No(2)......

14. If yes, where does the water come from?...

15. How frequent do you provide water?

It is always there	
Once per day	
Twice per day	
Once per two days or less	

16. What is the source of the water?..

17. How far is the water source from the homestead?...

18. Do guinea fowls survive during periods of water shortage? Yes (1)...... / No(2)......

19. Which category struggles with water shortage? (*Rank *1 = Struggles most*)

    Cockerels........Hens.........Keets.........

I. Opportunities and constraints

1. How has raising guinea fowls impacted positively on your livelihood?

More income	
More food	
Other (specify).............................	

2. How has raising guinea fowls impacted negatively on your livelihood?

Wake up early	
Disturb sleep	
Disturb visits to friends	
Disturb work in the fields	
Other (specify)...	

3. Can you please state and rank the major constraints you are facing in raising guinea fowls (*1 = The most faced constraint*)

Constraint faced	**Rank**

Lack of feed	
Lack of capital	
Lack of knowledge	
Preys	
Thefts	
Other, specify...	

4. How has raising guinea fowls negatively affected other domestic animals?

Reduce other fowl by incubating their eggs	
Reduced attention towards other animals	
Reduced capital for other animals	
Reduced feed for other animals	
Other (specify)..	

5. How has raising guinea fowls positively affected other domestic animals?

Increased protection for other fowl	
Increased capital that can be used by other animals	
Other (specify)...	

6. What complaints have you received from neighbours because of raising guinea fowls?

Noise	
Attack on their animals	

Feeding on their crops	
Other (specify)..	

7. What other comment would you like to make about raising guinea fowls?

....

....

....

Thank you

Appendix 2: Letter of acceptance from Journal of Applied Animal Research for manuscript entitled ‘‘Effect of age and sex on carcass characteristics and internal organ weights of scavenging chickens and helmeted guinea fowls’’

Journal of Applied Animal Research <onbehalfof+TAAR-peerreview+tandf.co.uk@manuscriptcentral.com>

09-Mar-2017
to me

Dear Mrs Musundire:

Your manuscript entitled "Effect of age and sex on carcass characteristics and internal organ weights of scavenging chickens and helmeted guinea fowls" has been successfully submitted online and is presently being given full consideration for publication in Journal of Applied Animal Research.

Your manuscript ID is JAAR-2016-0454.R1.

Please mention the above manuscript ID in all future correspondence or when calling the office for questions. If there are any changes in your street address or e-mail address, please log in to Manuscript Central at https://mc.manuscriptcentral.com/aar and edit your user information as appropriate.

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Thank you for submitting your manuscript to Journal of Applied Animal Research.

Sincerely,
Journal of Applied Animal Research Editorial Office