EFFECT OF FULL AND SEMI-SCAVENTING REARING SYSTEMS ON CROP CONTENTS AND THE QUALITY OF MEAT FROM VILLAGE CHICKENS DURING THE SPRING SEASON OF EASTERN CAPE, SOUTH AFRICA

BY

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Declaration

I, Charles Tawanda Hanyani, vow that this dissertation has not been submitted to any University and that it is my original work conducted under the supervision of Ms T.T Nkukwana and Prof. V. Muchenje. All assistance towards the production of this work and all the references contained herein have been duly accredited.

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Abstract

Effect of full and semi-scavenging rearing systems on crop contents and the quality of meat from village chickens in Spring of Eastern Cape, South Africa

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The objective of this study was to compare the nutrient status of full scavenging and semi-scavenging village chicken production systems. The semi-scavenging chickens were given broiler finisher mash between 14-24 weeks of age, whilst the full scavenging relied on natural foraging. The study also sought to compare the quality of meat from chickens from the two systems. After slaughtering the chickens, the crop contents were physically separated and analysed for chemical composition. Meat pH and colour were measured on the breast muscle of individual carcasses and a consumer sensory evaluation was also done on the breast muscle. The mean crop content weights per day were significantly higher in full scavenging chickens (±16.7g/day biomass) than in semi-scavenging chickens (±9.14g/day). Dry matter, calcium, and phosphorus levels were higher in the crop contents of the full than in the semi-scavenging chickens but crude protein, crude fibre and metabolisable energy were higher in the latter system. Semi-scavenging (1.3 ± 0.05kg) carcasses were heavier (P<0.05) than full scavenging ones (1.0 ± 0.06kg). The ultimate pH (24h) (pH_u) of meat from full scavenging chickens (6.0 ± 0.03) was higher (P<0.05) than that of meat from the semi-scavenging chickens (5.7 ± 0.04). Meat from the full scavenging chickens had higher L* values (60 ± 1.2) than meat from the semi-scavenging chickens (47 ± 0.8). The a* value of meat of full scavenging chickens was significantly (P<0.05) less (4 ± 0.4) than that of meat from semi-scavenging chickens (15 ± 1.3). There was a significant positive (0.60) correlation between
pH<sub>u</sub> and L* of meat from village chickens across rearing systems. The semi-scavenging system meat had better sensory attributes than the meat from the full scavenging system. Female consumers scored the typical flavour of village chicken meat across rearing systems higher (P< 0.05) than male consumers. The Shona consumers scored the meat higher (P< 0.05) than the Xhosa, Zulu, Ndebele and other tribes for initial juiciness, first bite impression and muscle fibre and tenderness of the chicken across rearing systems. Consumers scored of the meat from the semi-scavenging system higher (P<0.05) on initial juiciness (4.3 ± 0.20), first bite impression (4.2 ± 0.197), muscle fibre tenderness (4.5 ± 0.217) than meat from the full scavenging chickens. There were positive correlations (0.46) between aroma intensity and overall flavour intensity across both rearing systems. The semi-scavenging system produced better carcass characteristics, lighter (L*) meat and more consumer acceptable meat than full scavenging chickens. Therefore the full scavenging rearing system had better nutrient composition in its scavenging feed resource base, although the semi-scavenging systems produced chickens with better carcass, meat pH, colour and sensory characteristics than the full scavenging chickens.

**Keywords:** village chicken, production system, scavenging feed resources, nutrient status, ultimate pH, meat colour, consumer perception
List of Abbreviations

FAO - Food and Agriculture Organisation

GLM - Generalised linear model

IFPRI - International Food Policy Research Institute

ME - Metabolisable Energy

NRC - National Research Council

PROC CORR - Procedure of correlation

PROC - Procedure

SFRB - Scavenging Feed Resource Bases

SAS - Statistical Analysis System
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CHAPTER 1: Introduction

1.1 Introduction

Village chickens are an important source of high-quality protein for the ever increasing rural and urban population and further provide the former with additional income, especially to the resource-poor communities (Goromela et al., 2006). Village chickens in Africa are in general hardy, adaptive to rural environments, survive on little or no inputs and adjust to fluctuations in feed availability (Gichohi and Maina, 1992). Village chickens have a natural tendency to scavenge for their food resources. There has been a renewed enthusiasm in animal products that come from organic systems or the so-called ‘natural’ systems (Hoffman et al., 2003). The recognized importance of village chickens in providing meat, cash income, socio-cultural values to rural people and their efficient scavenging system has led to increased research on the species during the past 10 years (Gondwe and Wollny, 2005). In most African countries there are two traditional poultry production systems (free-range and semi-scavenging systems), which are characterized by a low plane of nutrition that varies with season (Mwalusanya et al., 2002; Goromela et al., 2006). The free-range or full scavenging production system is characterised by flocks of 1-10 birds, growth rates of 5-10g day\(^{-1}\), and high mortality rates whilst the semi-scavenging (backyard system) is characterized by flocks of 10-50 birds, growth rates of 10-20g day\(^{-1}\), and moderate mortality rates. The semi-scavenging chickens are supplemented with locally available feedstuffs or with commercial feeds sometimes (Kityali, 1998; Sonaiya et al., 1999; Riise et al., 2004).

For better production of the local and locally adapted chickens, feed supplementation should be considered according to the probable nutrient requirements of the birds and what the birds get from the scavenging sources (Rashid et al., 2004). Much of the low productivity in village chickens under traditional scavenging systems is a result of poor quality and quantity of scavenging feed resources (Roberts and Guranatne, 1992; Tadele and Ogle, 1996). The
scavenging feed resource base (SFRB) is defined as those feed resources available at farm level that consists of household refuse and all the materials available in the immediate environment that the scavenging birds can use as feed (Goromela et al., 2006). The major feed sources for village chickens are worms, insects, seeds, green leaves and other plant materials available in the backyard (Mwalusanya et al., 2002). According to Ologhobo (1990), grains, bran and household food leftovers are occasional sources of supplementary feed in purely free-ranging systems.

The SFRB for village chickens varies immensely with season, climate and location. This has been reported in studies conducted in countries such as Ethiopia, Indonesia, Sri Lanka and Tanzania (Guranatne et al., 1993; Tadele, 1996, Mwalusanya et al., 2002). Although not clearly estimated, sufficient SFRB may be available to scavenging village chickens in the rainy season, but there is scarcity when it is dry, especially during the spring season when there are less crop residues and the plants are beginning to sprout. In the rainy season, insects/worms and green forage materials are in abundance whilst in the harvesting season there is a high supply of cereal grains and a low supply of green forages and insects/worms (Mwalusanya et al., 2002; Goromela et al., 2006).

The chemical composition of SFRB of crop contents in developing countries contains low amounts of protein (100g kg DM⁻¹), energy (11.2MJ kg DM⁻¹) on average and calcium and phosphorus content as low as 11.7 and 5g kg DM⁻¹, respectively (Tadele, 1996; Huque, 1999; Sonaiya et al., 1999; Rashid et al., 2005; Mwalusanya et al., 2002). Under traditional scavenging conditions in Kenya the protein requirement of a village chicken was 160g kg DM⁻¹ for optimum growth rates (King’ori et al., 2010). Under the same environment, energy requirements during the 5-8, 8-14 and 14-21 week growth periods were 12.6, 10.9 and 10.4MJ kg DM⁻¹ respectively (Chemjor, 1998; King’ori et al., 2010). Efficient strategies for
scavenging village chickens production can be developed if feed supplementation is done according to probable nutrient requirements of the birds and what the SFRB provides to the birds (Rashid et al., 2005).

The quality of meat from scavenging village chickens is strongly affected by the breed, feed, rearing system and age of the chicken (Wattanachant, 2008). Reports by Wattanachatt et al. (2002) and Od-Ton et al. (2004) indicated that more intensive rearing systems in Thai village chickens resulted in higher carcass weights. Rearing chickens with full feed supplements resulted in village chickens with high percentage of breast muscle, which was more tender and of a better quality than muscle from an extensive system (Wattanachatt, 2008). Furthermore, supplementing village chickens with commercial feed tended to give them more intramuscular fat and resulting in better sensory attributes (Wattanachatt, 2008). Consumers’ preferences for village chicken meat is attributed to leanness, flavour and presumed organic origin than broilers (Wattanachant et al., 2004). Consumers of the modern world have a revised interest in meat products that are organically produced and that are safe health wise (Horsted et al., 2011).
1.2 Justification

Resource-poor farmers can only improve the nutrition status of village chickens by feed supplements if the nutrient requirement of the birds is known. Information on nutrient intake and nutrient requirements of scavenging village chickens of the Eastern Cape Province is not known. A direct estimation of the nutrient content of the available scavenging feed resources is difficult and therefore the use of an indirect method focusing on the assessment of the nutrient status of the crop contents of the scavenging chickens is frequently used to gain an estimation (Momoh et al., 2010). Knowledge of the nutritional status of the SFRB available to village chickens in the province would allow resource-poor farmers to devise efficient feed supplementation programmes to improve economic parameters such as growth rates, carcass characteristics, physicochemical properties of meat and the sensory attributes of village chickens meat. Most of these parameters affect consumers’ preference and purchase of chicken meat and therefore a need to match consumer needs if the indigenous breed is to be commercialized. If village chickens are of good market live and carcass weight, have better appearance and sensory characteristics, they will fetch higher prices and therefore improve the economic returns of resource-poor farmers.

Village chickens are a major source of protein and income in rural communities (FAO, 2003, 2010) and therefore it is important to know the effect of different feeding systems on the carcass characteristics, physicochemical properties and sensory characteristics of village chicken meat. This will improve the social, economic and nutrition status of these communities. Most studies on village chickens tend to look at production trends without considering critical periods such as the spring season and meat quality characteristics such as flavour, aroma and off-flavour descriptors (Dyubele et al., 2010; Chulayo et al., 2011).
The broad objective of the study was to compare; the nutrient status of the free-ranging and semi-scavenging systems and the carcass, physicochemical and consumer sensory characteristics of village chicken meat from two production systems during the spring season.

The specific objectives of the study were:

- To compare the nutritional status of full scavenging and semi-scavenging production systems using crop contents.

- To compare carcass characteristics, meat ultimate pH, colour and consumer sensory characteristics of meat from full scavenging village chickens and semi-scavenging village chickens.

1.3 Null hypotheses:

1. No significant differences exist in nutrient composition of fully and semi-scavenging village chickens crop contents.

2. There are no influential differences on carcass, physicochemical and sensory characteristics of fully and semi-scavenging village chicken meat.
1.4 References


CHAPTER 2: Literature Review

2.1 Introduction

Village chickens (*Gallus domesticus*) are the predominant poultry species in Africa (Andrews, 1990; Jalaludin, 1992). Traditional poultry systems in rural and peri-urban areas in most of Africa account for up to 80% of the poultry population (Gueye, 1998; Branckaert *et al.*, 2000). These systems are based on low input/low output scenarios and they contribute significantly to family nutrition and also present a source of income for resource-poor communities. Furthermore the performance of village birds varies from one area to another and this is due to the availability of scavenging feed resources (Mwalusanya *et al.*, 2002).

Village chickens in Africa have been defined as any genetic stock, improved or unimproved, that was raised extensively or semi-intensively in relatively small numbers (Sonaiya, 2003). According to Naidoo (2003), village chickens are those chickens which are left to free-range or scavenge for food with little or no supplementation. Village chickens are among the most adaptable domestic animals that can survive cold and heat, wet and drought, sheltered in cages, unsheltered outside or roosting in trees (Naidoo, 2003).

Improved village chicken production in rural areas, such as the Eastern Cape Province, seems to be a viable approach to improving nutritional and economic status of the rural households. Improvement in genetic potential of the village chicken should be accompanied by a concomitant improvement in the standard of management with particular attention to their nutrient requirements in order to enhance food security and economic empowerment of the rural people.

Improved nutritional management is necessary to assist in achieving optimal performance in terms of diet intake, growth rate, feed conversion ratio, live weight, high meat yield and low mortality, especially when commercialization of the breed is of utmost importance. Such an
approach may help the farmers to improve productivity of their chickens. For a realistic improvement in the nutritional status of the village chicken population in South Africa through feed supplementation, the nutrient requirements for these birds should be known.

2.2 Village chicken production systems in Developing countries

Village chickens are mainly kept under the free-ranging or scavenging system. Moreover, the production system practised is closely related to the religious and socio-cultural activities of many farmers in developing countries (Kitalyi, 1998; Branckaert et al, 2000). Gueye (2000) identified four main poultry production systems in developing countries, namely; free-range, backyard (semi-scavenging), semi-intensive and the small-scale intensive systems. Of these four, the free-range and the backyard system are the main types of poultry husbandry in the traditional poultry systems of Africa (Gueye, 2000).

2.2.1 Free-range (Full-scale scavenging) system

This system is practiced by the majority of the rural families. Flock size may vary from an average of 1-10 birds of the indigenous poultry type per rural household (Kityali, 1998). Birds of all ages live and scavenge together. In this type of system birds are owned mostly by women and children for home consumption (protein), small cash income and cultural activities (Goromela et al., 2006).

The birds under the free-range are left to scavenge around the homestead during the day for household leftovers, waste products and environmental materials such as insects, worms, seeds, scattered grains and green forages (King’ori, 2004; Goromela et al., 2006). Chickens are not regularly provided with water and other inputs such as supplementary feeds, housing,
vaccination and medication. Drinking water is irregularly provided in tins or broken clay pot pieces (King’ori, 2004). If and when supplementary feeding is done; it is by provision of household wastes such as maize, canary seeds, cowpeas testa, millet, sorghum, ripe pawpaw seeds, cassava meal, cereal bran, oilseed meals, blood meal and fishmeal (Ahmed, 1990; Diambra, 1990; Nwosu, 1990; Moreki et al., 2010). Supplements vary according to season and availability.

The level of productivity in the free-range system is very low compared to the backyard system (Gueye, 2003). In layers, 30-50 eggs hen\(^{-1}\) year\(^{-1}\) are produced and growth rates average 5-10g day\(^{-1}\). Housing under this system is not developed and consists of simple structures such as half drums and wire cages that are used mainly to protect the birds from predators and weather extremes (King’ori et al., 2010).

Replacement stocks in the free-range system come from hatching own chicks or are purchased from the local market or from neighbours or given as gifts. Inbreeding is rife as the breeding stock is seldom replaced (Mburu, 1994). Chickens are regarded as insurance against unforeseen immediate cash needs such as medical and school fees (King’ori et al., 2010). According to Moreki et al. (2010), one or more chickens are sold to meet such expenses. Local traders buy live chicken and eggs from the resource-poor farmers and sell them to urban markets (Andrews, 1990; Nyaga, 2007). Live birds are sold when aged six months and over (Olaboro, 1990).

### 2.2.2 Backyard (Semi-scavenging) system

This is a system of chicken production practiced by a moderate number of rural households where families are more financially viable than the rest of the households that practice free-
ranging (Sonaiya et al., 1999; Gueye, 2003; Riise et al., 2004). In the semi-scavenging system, 5-50 birds are kept and these are mostly owned by women and children. Birds are semi-confined either within an enclosure made of locally available material of moderate cost, overnight shelters or with a fenced yard (Sonaiya et al., 1999). The chickens are left to scavenge during the day but have regular feeding schedules before and after each day’s scavenging. Supplementary feeding is usually grains, oilseed cakes and household waste or commercial feeds. Water and veterinary care is provided although not adequately and mortality is usually around 40-60% in young chicks (Ondwassy et al., 1999).

As part of breeding procedures, some form of cockerel exchange between farms happens. As a result of better management in this system, mortality is moderate and there is an increased egg production (50-150 eggs hen\(^{-1}\) year\(^{-1}\)) and growth rate (10-20g day\(^{-1}\)) (Kitalyi, 1998; Sonaiya et al., 1999; Guèye, 2003; Riise et al., 2004). The profit margins in this type of rearing are higher than in the free-ranging systems (Goromela et al., 2006).

To attain a balanced diet in order to improve their productivity, intensive rearing conditions seem to be the most viable options. Thus, it is very important to identify the nutrition gap in the various types of rearing systems and compare them to the recommended levels. This will allow smallholder chicken farmers to effect small management changes such as those practised under intensive rearing conditions which include; regular watering, continuous lighting, regular feeding regimes, and vaccination for common diseases for optimum productivity in scavenging village chickens.
2.3 Production and productivity of village chickens.

Productivity of village chickens has been reported to be low under full-scavenging or free-ranging conditions (Alders et al., 2001). Tadele et al. (2000) considered scavenging village chickens to be of low productivity in terms of poor growth rates, few eggs produced, high chick mortalities, susceptibility to diseases and long brooding periods. Other reasons for poor productivity of scavenging village chickens have been attributed to their poor food resource base, limited foraging ranges and poor management practices (Alders et al., 2001; Swatson et al., 2001). Even though these chickens can survive under harsh nutritional and environmental conditions (Tadelle and Ogle, 2001), it has been shown that their productivity under scavenging conditions is very low (Alders et al., 2001).

Village chicken productivity is also influenced by the type of production system practiced. Free-range chicken production has egg production of 30-50 eggs/hen/year and low growth rates of between 5-10g/day (Sonaiya et al., 1999; Guèye, 2003). Backyard rearing is better than free-ranging in terms of chicken productivity as it has an egg production capacity of 50-150 eggs/hen/year and improved growth rates of 10-20g/day (Kityali, 1998; Riise et al., 2004).

Dietary protein levels have been reported to have an effect on the productivity of scavenging village chickens. In studies by King’ori et al. (2003) on village chickens, feed intake per bird increased with increasing protein levels. As reported by Thamabood and Choprakan (1982), indigenous chickens given 10, 12 and 14% supplementary dietary protein besides their natural scavenging had growth rates of 10.6, 8.5 and 8.7g/bird/day. Therefore growth rate in village chickens was higher with a diet having higher protein density.
Improving the poultry productivity would improve protein nutrition and the income levels of the rural population. The productivity of village chickens can be improved by providing appropriate housing, disease control and good nutrition (Hinrich and Steinfield, 2007).

2.4. The Scavenging Feed Resource Base of Village Chickens

Scavenging is a major activity for extensively-reared village chickens in the resource-poor communities. Chickens under scavenging systems have the disadvantage of restriction on food quality and quantities. The locally available feed is known as the scavenging feed resource base, it comprises of household waste, crop by products and a range of food from gardens, fields and rangelands (Ahlers et al., 2009). As stated by Ologhobo (1990), the major source of feed for village chickens are worms, insects, seeds, green leaves and other plant materials found in the backyards. The scavenging resource base (SFRB) varies from one region to the other, depends on season, climate of the area and with the size of the area chickens have to roam around.

2.4.1 Season, climate and altitude

According to Ahlers et al. (2009), SFRB is greater during the wet season, it reaches its peak amount during the harvest season and it generally declines during the dry season. Mwalusanya et al. (2002) reported that availability of grains was higher in the long rainy season (as harvesting takes place), than in the short rainy season. The higher dry matter in chickens’ crop contents during the harvesting season than in the non-harvesting is due to the availability of grains in the harvesting period (Rashid et al., 2005). In another study, the higher amounts of cereal grains in the harvesting season than the non-harvesting season, was
associated with increased availability of cereal grains which had just been harvested and frequently given to the birds (Mekkonen et al., 2010). Guranatne et al. (1993) and Tadele (1996) observed that planting and harvesting periods influenced crop contents of scavenging village chickens. Most previous studies indicated that the higher proportion of green forages, found in crop contents of most village chickens during the non-harvesting season, was because of the large consumption of young sprouts which were abundant during this period (Mekkonen et al., 2010). Calcium and phosphorus were reported to be found in higher quantities in the crop contents of scavenging chickens in the non-harvesting season. This can be attributed to the abundance of green forages during the same period. Green forages are reported to have high amounts of calcium and phosphorus (Ali, 1995). In high altitude regions there is a high amount of grains and forages compared to low altitude areas. Type of altitude seems to have no difference on the availability of insects and worms (Tadele, 1996).

2.4.2 Type of bird (genotype and physiological status)

Rashid et al. (2005) reported that the scavenging feed resource base could vary with the type of birds due to their foraging behaviour and stage of growth. Layers have a tendency of consuming more crude protein, calcium and phosphorus than growers and this is explained by that layers have a selective feeding habit which is influenced by age of the chicken and production stage. Leeson and Summers (1997) concluded that if scavenging village chickens are given a choice in feeding, hens are likely to pick calcium-rich feedstuffs than growers. This is also in agreement with studies in Sri Lanka by Guranatne et al. (1993).
2.4.3 Scavenging feed resource base quantities of biomass

The amount of scavenging material available to each indigenous chicken per day is important in smallholder chicken production. In Nigeria, the SFRB estimated for four villages was 110kg dry weight of biomass/family flock/year (Sonaiya, 2003). Studies by Gunaratne et al. (1993) reported 197kg/year; Javiriyasopak et al. (1989) reported 390kg/year while Kingston and Creswell (1982) reported 475kg/year. The wide variation in SFRB between regions was attributed to different environments (Sonaiya et al., 2002). As concluded by Guranatne (1999), the SFRB of any traditional poultry system is dependent on extrinsic factors such as seasonal variables and levels of predation, health, scavenging behaviour, age and physiological status of the scavenging birds. Large amounts of SFRB biomass do not directly translate to good quality nutrients from the scavenging feed resources. This was reported by Sonaiya et al. (2002), for 475kg SFRB biomass available per year, on average 21g crude protein is available to a flock of 12 birds of the indigenous chickens and this translates to 2g C.P available to each bird/day.

2.4.4 Flock biomass and its management

Flock biomass has been defined as the total live weight of a flock of chickens per particular household. The availability of SFRB can be determined by the total biomass of scavenging poultry than can be optimally supported by the available feed resources. Roberts (1995) describes the village community in terms of families which discard household refuse and which then becomes available to the village chicken flock as SFRB, whilst the other remaining part of the SFRB comes from the environment (Goromela et al., 2006). The biomass of the village flock, which is the sum of the flocks of those families in the village which keep chickens, will be supported by the available SFRB (Roberts, 1995). The problem
comes if the village flock biomass exceeds the carrying capacity of the SFRB, as there will be competition among chickens of different sex and ages for the available household refuse and environmental feed. Consequently it disadvantages chicks and growers as they are the weakest members of the village flock and cannot compete with adult chickens for SFRB.

In study in Nigeria by Sonaiya et al. (2002b), the quantity of SFRB available for a chick was 0.996kg/year whereas a hen had 11.04kg/year in a traditional scavenging system. This shows that chicks and growers consume less amount of SFRB with low quality. According to Roberts (1999), chicks and growers grow slowly and the weaker birds may die due to starvation when there is strong competition for SFRB.

2.5 Nutritional Requirements and Management

Nutritional requirement has been defined as the amount of nutrients needed by animals to maintain their activities, maximize growth and feed utilization efficiency, improve laying capacity and hatchability and optimize fat accumulation (Laohakaset, 1997; Chirasri, 2004). Adequate nutrition is a key factor in determining performance and productivity of chickens (Larry, 1989). There is a need therefore to formulate diets that will meet all the nutritional needs for chicken growth.

2.5.1 Protein requirements

Protein requirements in chickens vary partly according to the physiological state of the bird, that is, the rate of growth or egg production. Age, body size, sex and breed are other factors that contribute to variations in protein requirements for chickens (Kingori, 2004). For instance, indigenous chickens such as the Venda breed require less protein to meet their
needs because of their slow growth rate and small body size (Safaloah, 2001). Tadele and Ogle (1996) reported that the protein requirement of village chickens varies between 16 and 18% during the growing phase for optimal performance.

Dietary protein levels of 130g/kg of feed between 14 and 21 weeks growth stage are adequate for scavenging village chickens (Chemjor, 1998). In Kenya, growing indigenous chickens require 160g/kg of feed of crude protein. In the same study, it was indicated that indigenous laying hens require 120g/kg (feed) crude protein (Kingori et al., 2003). Growth rate and feed conversion ratio of indigenous chickens improved as dietary protein levels increased up to 160g/kg crude protein. This may be a result of an increase in available protein and amino acids for growth.

Ndegwa et al. (2001) observed that if indigenous chickens are fed diets of 17-23 crude protein, their growth rate and feed intakes are similar and it means that 17% crude protein is adequate for these chickens. Information on supplementary protein needs of scavenging village chickens is limited and varies widely. Supplementary dietary protein requirements therefore need to be accurately determined for optimal productivity.

### 2.5.2 Energy requirements in village chickens

In poultry, feed intake is determined by the amount of energy in the diet (Nahashon et al., 2006). The energy requirements of poultry are often expressed in terms of metabolizable energy per day (Smith 1990). It has been shown that increasing the dietary energy concentration leads to a decrease in feed intake and vice versa and thus resulting in reduced growth (Veldkamp et al., 2005). In a study by Rashid et al. (2005) upon analysing crop contents of village chickens, calculated metabolisable energy (ME) was 11.49MJ/kg D.M.
Chicken requirements for egg production are 11.3 to 11.5 MJ/kg ME (Daghir and Jones, 1995).

Since village chickens mainly scavenge in order to obtain feed, the scavenging feed resources are not concentrated enough in terms of energy because they do not contain sufficient quantity of starch and they have high fibre content. Cereals have high amounts of crude fibre and cellulose (20-30%) (Kondombo, 2005). High crude fibre means more cellulose, lignin and hemi-cellulose that cannot be digested efficiently by monogastric endogenous enzymes; this progressively reduces the digestibility of the diet (Mekkonen et al., 2010). Scavenging birds consume additional energy for scavenging energy activities and stop feeding when the crop and gizzard are filled to capacity (nibbling) (Minh et al., 2006).

In most studies conducted in developing countries, the energy found in the crop contents was lower than that recommended by NRC (1994) for both layers and growers (2900kcal and 2850kcal, respectively). Payne (1990) recommended 2643kcal and 2595kcal, for layers and growers respectively. Metabolisable energy levels of 11.46MJ/kg D.M feed was recommended during the 1-6 weeks of growing period and 10.86MJ ME/kg D.M feed during the 6-12 weeks growing period (Payne, 1990). According to Kingori (2004), the daily energy requirement by indigenous chickens for maintenance is about 480KJ/d and more than 953KJ/d to support maximum egg laying and also energy is needed for scavenging activites.

2.5.3 Calcium and Phosphorus requirements

Calcium and phosphorus are mainly required for the growth and development of the chicken skeletal system. Furthermore, laying hens require calcium and phosphorus for egg production
activities. It is important for these two minerals to be supplied in adequate quantities and appropriate ratios for the successful production of village chickens.

In Ethiopia, Mekkonen et al. (2010) reported that calcium content varied from 0.43% to 0.90% of dry matter (D.M), which is close to that reported by Tadele and Ogle (2000) (0.2-0.9%). This was lower than the reports of Rashid et al. (2004) (1.32%). The phosphorus content reported by Mekkonen et al. (2010) (0.24%-0.38%) was lower than that of Tadele and Ogle (2000) (0.6%). McDonald et al. (2002) recommended minimum phosphorus requirement of 0.5% and stated that the calcium level must be much higher for eggshell formation.

Most scavenging feed resources of village chickens in developing countries are deficient in calcium and phosphorus, which are both required for optimum egg production and growth (Mekkonen et al., 2010). Supplementing calcium-phosphorus rich feeds would probably result in increased egg production and optimum growth of scavenging village chickens in developing countries.

2.5.4 Crude fibre requirements of scavenging village chickens

Green forages have been reported to have a higher value of crude fibre than cereal grains (Ali, 1995). High crude fibre content in scavenged feed has adverse effects on feed digestibility and the nutrient intake of indigenous chickens (Longe and Ogedegbe, 1989). In most studies, the scavenging feed resource base has been found to contain high amounts of crude fibre as Mekkonen et al. (2010), Rashid et al. (2005) and (Mwalusanya et al. 2002;) found significantly higher crude fibre content in chickens crop contents than maximum levels (5%) recommended for commercial layer rations (Feltwell and Fox, 1978). Fibre is composed
of cellulose, lignin and hemi-cellulose that cannot be digested efficiently by monogastric endogenous enzymes; the increase in crude fibre means the digestibility of the diet diminishes progressively (Mekkonen et al., 2010)

2.6 Challenges and opportunities of chicken production

Indigenous chickens provide major opportunities for increased protein production and income for smallholders (Gous et al., 1999). Chickens have a short generation interval and a high rate of productivity. They can also be transported with ease to different areas and are relatively affordable and consumed by the rural people as compared with other farm animals such as cattle and small ruminants. Chickens also play a complementary role in relation to other crop livestock activities. Indigenous chickens are good scavengers as well as foragers and have high levels of disease tolerance, possess good maternal qualities and are adapted to harsh conditions and poor quality feeds as compared to the exotic breeds. In some communities, village chickens are important in breaking the vicious cycle of poverty, malnutrition and disease (Sonaiya et al., 1999). In South Africa, however, lack of knowledge about poultry production, limitation of feed resources, prevalence of diseases (Newcastle, Coccidiosis, etc) as well as institutional and socio-economic constraints (Sonaiya et al., 2000) remains to be the major challenges in village based chicken productions. Most village chicken farmers in the developing countries are not concerned about the biosecurity level of their farms and do little to prevent diseases spreading. Diseases have a compound effect on productivity traits such as growth rate, egg production, and meat quality. The money spent on disease control is insignificant and chicken mortalities are high ranging from 40 to 60% (Ondwassy et al., 1999). Pests and insects can cause high mortalities in chicks and can be reduced by good sanitation and regular removal with insecticides.
2.6.1 Water availability

One of the most neglected nutrients for chickens is water. Esmail (1996) stated that water is the most important of all nutrients. Water serves as a medium in which nutrients are transported, waste eliminated and body temperature maintained. Smith (1985) reported that most people realize that all living organisms contain a high percentage of water. Younger animals tend to have a higher percentage of water than older animals of the same species. A one-week-old chicken consists of about 85% of water while a 32-week-old Leghorn hen contains about 55% water. The above-mentioned percentages were also confirmed by Wallner–Pendleton and Scheideler (1995).

Furthermore Esmail (1996) reported that a lack of water would, therefore, have a more immediate and drastic effect on body physiology than the lack of any other nutrient. If a bird loses 10% of its body weight from dehydration it will be seriously weakened and if it loses 20% it will probably die (Abbas et al., 2009).

2.7 Meat Quality attributes of Village chickens

White meat such as chicken meat is known for its superiority in health aspects compared to red meat because of its comparably low content of fat and cholesterol (Jaturasitha et al., 2007). Shaarani et al. (2006) reported that cholesterol was far lower in the breast and thigh meat of the indigenous chicken strains compared with the imported breeds. In a study by Jaturasitha et al. (2008), meat from Black-boned chickens had relatively low contents of saturated fatty acids which provide a successful product for a niche market serving consumers who prefer low fat chicken meat. Meat quality is determined amongst others by
age, breed, nutrition, and management. It is believed that meat quality is a function of the rate of pH decline and the ultimate pH (Sales and Mellett, 1996; Hambrecht et al., 2004; Muchenje et al., 2009b). The rate of decline in pH influences the colour and drip loss of meat (Aberle et al., 2001; Muchenje et al., 2008a). The following are important physical meat quality attributes in chickens; post-mortem pH, breast and thigh colour, meat texture and water holding capacity.

### 2.7.1 Post mortem pH changes in meat

Post-mortem pH decline has an impact on other attributes of meat quality such as meat texture, colour and water-holding capacity. The rate of pH decline in meat is due to the fact that glycogen in the slaughtered animal is converted to glucose. The glucose undergoes glycolysis in the absence of oxygen which results in the formation of lactic acid. The lactic acid build-up causes a drop in pH in muscle and this helps in the conversion of muscle to meat (Muchenje et al., 2009a). According to Castellini et al. (2002), the ultimate pH influences the structure of myofibrils and therefore the water holding capacity and meat colour. A low pH is associated with poor water holding capacity and poor functionality (Owens et al., 2000; Woelfel et al., 2002) and a high pH is related to poor shelf life because it is a conducive environment for bacterial growth. Slow-growing village chickens are more susceptible to shackling stress than fast-growing broiler breeds. In village chickens shackling stress results in faster breast muscle acidification whilst in exotic breeds’ the pH decline is much slower (Debut et al. 2005). Village chickens exercise more than exotic commercial breeds which are in confinement for most of their production life-time, therefore outdoor access results in lower pH in chicken muscle of slow-growing indigenous chickens than fast-growing exotic breeds (Culioli et al., 1990; Castellini et al., 2002a).
2.7.2 Water Holding Capacity (WHC)

Water holding capacity (WHC) is defined as the ability of meat products to maintain water within their fibers (Fennema, 1990). Mendes et al. (2003) stated that WHC can be estimated by the difference in weight of the Pectoralis muscle before and after cooking. In a study by Fanatico et al. (2007) slow-growing chicken genotypes had higher cooking loss than the fast-growing genotypes such as broilers. Chatrin et al. (2006) found out that cooking loss was greater in breast muscles that contained high lipid levels. Previous studies by Lonergan et al. (2003) and Fanatico et al. (2005a) indicated a higher cooking loss in slow-growing village chickens than fast-growing broiler chickens; a phenomenon related to the higher fat content in the fast growing chickens. If total moisture loss is considered, slow-growing genotypes lose more moisture than the fast-growing genotypes. Santos et al. (2005b) discovered that the breast meat of a slow-growing genotype had poorer WHC than a fast-growing genotype. Production system is another factor that impacts on WHC, indoor fast-growing broiler chickens have been seen to have more drip loss than slow-growing village chickens (Fanatico et al., 2007).

2.7.3 Tenderness

Meat tenderness is defined as the ease of mastication, furthermore it is a function of collagen content and its heat stability and the myofibrillar structure of a muscle. Meat tenderness significantly improves with aging of muscle due to the breakdown of myofibrillar proteins by collagenase enzymes produced by bacteria in meat (Zhang et al., 2005; Muchenje et al., 2008a, b). Texture, particularly tenderness is an important attribute that consumers consider when purchasing chicken meat (Fanatico et al., 2007). Meat tenderness also depends on
muscle type and the more tender the meat the more acceptable it is to consumers (Waskar et al., 2009). Shear force needed in the cutting of breast meat of village chickens is higher than that needed for exotic breeds. The more an indigenous chicken scavenges, the more the lactic acid that builds-up, the higher the pHu and subsequently the less tender the meat (Nute, 1997; Wattanachant et al., 2004; Jaturasitha et al., 2008).

2.8 Summary of literature

Village chicken production has a number of constraints that include poor nutrition, genetic improvement, housing, diseases and management. Inadequate nutrition is the major factor that reduces productivity of scavenging village chickens as it negatively impacts on growth rate and meat quality. Village chickens mainly rely on scavenging feed resources which are in turn affected by the following factors; climate, season, geographic locations, and then the age, breed, sex and foraging behaviour of the animal. Given that poor and inconsistent nutrient supply to village chickens hinders productivity, it is therefore necessary to investigate the effect of different feeding conditions on meat quality of village chickens. Constant and balanced nutrient supply to scavenging chickens may be helpful in terms of improving their economically important traits such as carcass weight, meat colour, ultimate pH and sensory characteristics of village chicken meat. This can end in the long-term goal of commercialization of village chickens at a more profitable scale.


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CHAPTER 3
Comparison of physical and chemical composition of the crop contents of full and semi-scavenging village chickens in spring in the Eastern Cape Province, South Africa

Abstract

The objective was to compare the nutritional status of chickens scavenging feed resources in full scavenging and semi-scavenging rearing systems. In the study 30 chickens from the full scavenging system and 30 chickens from the semi-scavenging system were purchased and slaughtered. The mean weight of crop contents were 9.1(±1.24) g/kg biomass for semi-scavenging and 16.7(±1.65) (g/kg biomass) for full scavenging respectively. The total weight of cereal grains, forages, insects/worms and eggshells in the crops’ of the chickens were higher (P< 0.05) in the full scavenging (81.5g/kg biomass) than in the semi-scavenging (55.7g/kg biomass) chickens. Cereal grains were more abundant (P< 0.05) in the crops of the full scavenging (20.2g/kg biomass) than in the semi-scavenging (13.4g/kg biomass) chickens. Green forages weight was significantly (P< 0.05) higher in full scavengers (18.6g/kg biomass) than in the semi-scavengers crop contents (10.7g/kg biomass). Insects/worms weight was higher (P< 0.05) in the full scavenging (19.3g/kg biomass) than in semi-scavenging (11.2g/kg biomass). Eggshells weight was higher (P<0.05) in the full scavengers crop contents (4.01g/kg biomass) than in the semi-scavengers (2.17g/kg). Dry matter, calcium, and phosphorus levels were higher in the full than in the crop contents of semi-scavenging chickens but crude protein, crude fibre and metabolisable energy were higher in the semi-scavengers crop contents. Crude protein, crude fibre, and phosphorus % levels were below the requirement for optimal chicken growth. The scavenging feed resource base of both rearing systems was deficient in these nutrients, although calcium was adequate in the
semi-scavenging system. The semi scavenging system had higher crude protein, crude fibre and metabolisable energy which are reflected by the higher carcass weight in the chickens.

**Keywords:** crop content, village chicken, rearing system, South Africa
3.1 Introduction

Village chickens, which are managed under extensive systems account for 80% of the total chicken population in rural Africa (Gueye, 2000). Village chickens provide a source of protein for the increasing rural population and they also create employment and generate family income (Dyubele et al., 2010). Furthermore, the village chickens are good scavengers and foragers, well adapted to harsh environmental conditions and their minimal space requirements and they are preferred by rural farmers as they are not capital intensive to make chicken rearing a suitable activity (Muchadeyi, 2007; FAO, 2010). Village chickens in South Africa are kept under the traditional system where they scavenge for most of their feed with little or no supplementation. The village chickens’ nutritional requirements tend to be overlooked by smallholder farmers and this tends to affect their performance and productivity thereby impacting on family income as the market weights required are not reached in most cases. The scavenging feed resources available to village chickens in many countries such as Ethiopia, Indonesia, Sri Lanka and Tanzania are influenced by factors such as season, climate and location. In Bangladesh, the nutritional status of scavenging village chickens was lower in the non-harvesting season than the harvesting season (Rashid et al., 2005). In the rainy season, there is an abundance of insects, worms and green forage materials whilst in the dry season there is a high supply of cereal grains and cereal by-products and a low supply of insects, worms and green forages (Goromela et al., 2006). Furthermore, a bird kept under free-ranging or semi-scavenging systems cannot find all its required nutrients all year round.

In a study by Mekonnen et al. (2010), crude protein, calcium and phosphorus levels were below the requirements for egg production and growth. These findings are in agreement with others (Huque et al 1994; Tadele, 1996; Huque, 1999; Mwalusanya et al., 2002; Rashid et al., 2005) who reported that the scavenging feed resources vary and are critically deficient or
unbalanced with season. According to Ajuyah (1999), accurate estimation of the quantity and quality of the feed in the materials scavenged by village chickens are important prerequisites for improving feeding systems and management, in terms of effective feed supplementation. Knowledge and understanding of the chicken crop and gizzard contents provides the resource poor farmers with information on whether they are adequately supplementing the necessary nutrients in the correct quantities. This will help in the designation of efficient feed supplementation schemes by these farmers and such studies are lacking in Eastern Cape Province of South Africa. Hence, this study was carried out to compare the nutritional status of the scavenging feed resources in two rearing systems by physical and chemical analysis of village chickens’ crop contents.

3.2 Materials and methods

3.2.1 Description of the site

The chickens were raised at two different farms in the Bhisho area while physical and chemical crop content analysis was conducted at the University of Fort Hare in Alice town which falls under the Amathole District, Eastern Cape, South Africa. The Bhisho area is located 399m above sea level, lies at latitudes of 32° 52’ 0S and longitudes 27° 25’ 60E. Bhisho receives an average annual rainfall of 476mm and the dry Great Karoo dominates the region. The Great Karoo vegetation is composed of trees, shrubs and plant species such as *Themeda triandra*, *Panicum maximum*, *Digitaria eriantha*, *Eragrostis spp*, *Cynodondactylon* and *Pennisetum clandestinum* are the dominant plant species. It receives the lowest rainfall (7mm) in July and the highest (73mm) in March. The average midday temperatures for
Bisho range from 19.6°C in July to 26.5°C in February. The region is the coldest during July when temperature drops to 6.4°C on average, during the night.

3.2.2 Birds and crop content collection

A total of 60 six-months old village chickens were purchased from two farms in the Bhisho area of the Eastern Cape. From the 60, 30 chickens were being reared under a full scavenging system and they were purchased from the community and the other 30 (semi-scavenging system) were purchased from a poultry farmer. The birds in the semi-scavenging system were housed in brick wall poultry houses with a clean water supply. These birds were fed with broiler finisher mash (Epol Feeds. Co) which contained (18% crude protein, 5% crude fibre, 5% Ca and 2.5% P) from 16 weeks to time of slaughter (24 weeks); feed was approximately 60g/bird/day. Semi-scavenging chickens were fed twice per day; at 8.00a.m and at 5p.m. after the day’s scavenging, they were housed in farm-house brick pens which measured (7m x 2m) Whilst the 30 full scavenging were not provided with housing and water at all and occasional supplementation with maize was done. The chickens were collected after 5 p.m. when they were done with the day’s scavenging and were taken to the slaughterhouse. All the birds were transported in cages in a truck to the slaughterhouse. The chickens were slaughtered 2 hours after arrival. Slaughtering was done by stunning each chicken individually on the head in isolation for it to be unconsciousness and then slaughtered. The chickens were allowed to bleed for five minutes to enhance tenderness (Chulayo et al., 2011). Boiled water was used for the easy plucking of feathers after which the chickens were eviscerated.

The crop content of individual birds was visually and individually separated into different categories (grains, kitchen wastes, insects and worms, green forage and others). The crop contents of each bird were weighed individually using an electronic balance (± 0.001g)
(Mettler Toledo®-Classic MS Series Semi-Micro Balance.). The gizzard contents were not collected or weighed as the amount of feed present in gizzards was too insignificant for analysis. Each chicken’s crop contents was placed in plastic containers and stored in a refrigerator at -20°C.

3.2.3 Chemical analysis of crop contents

The chemical analyses were done at Quantum Laboratories in Malmesbury, Western Cape. The analyses were according to the standards of the Association of Official Analytical Chemists (AOAC, 1990). The dry matter (DM) was determined by oven drying at 103°C for 18h to a constant weight. In crude protein determination the sample is combusted at 900°C in the presence of pure oxygen to nitrogen, carbon dioxide and water. The nitrogen is measured by a thermal conductivity detector after selective removal of the carbon dioxide and water. A factor of 6.25 based on sample type is used to convert the nitrogen to crude protein. Crude fat was determined by the ANKOM XT15 extraction system (ANKOM, AOCS Am5-04). Crude fibre was determined by hydrolysis with hot acid and alkali to remove protein, fat, starch and other digestible carbohydrates, and the loss on ignition determines crude fibre (ANKOM, AOCS Ba 6a-05). Ash content was determined by heating a sample in oven at 600°C. Calcium was determined by a peroxy-sulphuric digest in a Technicon Auto Analyzer (506-77A). Phosphorus was determined by a peroxy-sulphuric digester system (Method 8190 Hach Corporation).

The true metabolisable energy (TME) of the crop contents was calculated using an indirect procedure as described by Wiseman (1987):

\[
TME \text{ (kJ/kg D.M)} = (3951 + 54.4EE - 88.7CF - 40.8Ash) \times 4.184
\]
Where EE, C.F and Ash are in percentage of D.M. The metabolisable energy (ME) was determined by assuming that TME is 8% higher than ME (Rashid et al., 2005).

3.2.4 Statistical Analysis

The data collected were analysed using SAS (2003) General Linear Models (GLM) procedure based on the following statistical model:

\[ Y_{ij} = \mu + s_i + e_{ij} \]

Where,

\( Y_{ij} \) = an observation for a given variable (dry matter, ash, crude protein, crude fibre, crude fat, calcium, phosphorus)

\( \mu \) = overall mean

\( s_i \) = effect of the \( i^{th} \) rearing system (\( i = 1.\) full scavenging, 2. semi-scavenging)

\( e_{ij} \) = residual random error.
3.3 Results

Live and carcass weights of chickens

The live weights of the chickens were 2.08 (±0.07) and 1.75 (±0.08) (standard error) kg for full scavenging and semi-scavenging production systems, respectively. The carcass weights of the full scavengers were lower (P< 0.05) than those of the semi scavenging chickens.

Physical composition of crop contents

The mean weights for the crop contents of the full scavenging chickens were higher (16.7 g/day) than the 9.14 (g/day) semi-scavenging village chickens respectively (Table 3.1). The main constituents of the crop contents of the chickens were visually categorized into cereal grains (maize, sorghum), green forages, insects, kitchen wastes and egg shells.

The weight of the cereal grain, forages, insects and egg shells was heavier (± 81.5g/kg biomass) in the full-time scavenging birds than in the semi-intensively reared chickens (± 55.7g/kg biomass). Traces of commercial feed (broiler finisher mash) were observed in the crop(s) of the semi-intensively reared village chickens. Cereal grains were found to have significantly higher weights in the full scavenging than the semi-scavenging rearing system (P < 0.05). Insects and worms had a significantly higher weight in full-time scavengers than in the semi-scavenging chickens (P < 0.05). Overall, crop contents varied with rearing system.
Table 1 Means of physical crop contents of village chickens reared under full and semi-scavenging conditions

<table>
<thead>
<tr>
<th>Physical component (g/kg)</th>
<th>Rearing system</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full scavenging</td>
</tr>
<tr>
<td>Cereal grains</td>
<td>20.2 ± 4.33</td>
</tr>
<tr>
<td>Forages(green)</td>
<td>18.6 ± 3.09</td>
</tr>
<tr>
<td>Insects/worms</td>
<td>19.3 ± 5.01</td>
</tr>
<tr>
<td>Kitchen waste</td>
<td>19.4 ± 3.15</td>
</tr>
<tr>
<td>Egg shells</td>
<td>4.0 ± 2.24</td>
</tr>
</tbody>
</table>

Means with different superscripts within a row are significantly different at P< 0.05
Proximate Composition of Crop Contents

The results of the effect of type of rearing system on the chemical composition of the crop contents of chickens are presented in Table 3.2. Ether extracts were significantly higher (P <0.05) in the full scavenging than in the semi scavenging system. The crude fibre levels were significantly higher in the full-time scavenging village chickens compared to the semi-intensively reared ones. The calcium and phosphorus percentages were higher (P< 0.05) in the full scavenging production system than in semi-scavenging rearing system. There were also significant differences in the metabolisable energy content of the diets from the two systems, as that of full-time scavenging was higher than the semi-intensively reared chickens (P<0.05). However, there were no significant differences in the crude protein and dry matter levels.
Table 3-2 Means of proximate crop contents of village chickens reared under full and semi-scavenging rearing systems

<table>
<thead>
<tr>
<th>Chemical composition (%)</th>
<th>Rearing system</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full-scavenging</td>
</tr>
<tr>
<td>Crude Protein</td>
<td>6.9&lt;sup&gt;a&lt;/sup&gt; ± 1.84</td>
</tr>
<tr>
<td>Dry matter</td>
<td>60.1&lt;sup&gt;a&lt;/sup&gt; ± 3.60</td>
</tr>
<tr>
<td>Fat</td>
<td>2.4&lt;sup&gt;a&lt;/sup&gt; ± 0.80</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>4.2&lt;sup&gt;a&lt;/sup&gt; ± 0.83</td>
</tr>
<tr>
<td>Ash</td>
<td>5.4&lt;sup&gt;a&lt;/sup&gt; ± 1.18</td>
</tr>
<tr>
<td>Ca</td>
<td>0.5&lt;sup&gt;b&lt;/sup&gt; ± 0.60</td>
</tr>
<tr>
<td>P</td>
<td>0.2&lt;sup&gt;b&lt;/sup&gt; ± 0.06</td>
</tr>
<tr>
<td>ME (kcal/kg)</td>
<td>1974&lt;sup&gt;a&lt;/sup&gt; ± 56.7</td>
</tr>
<tr>
<td>Ca: P ratio</td>
<td>2:1</td>
</tr>
</tbody>
</table>

Means with different superscripts within the same row are significantly different at P< 0.05
3.4 Discussion
The mean live weights of 2.0 ±0.07 kg for full-time scavenging and 1.7 ±0.08 kg for semi-scavenging birds in the present study is in agreement with what Gueye (1998) reported. The later reported 0.7 to 2.1 kg live weight for adult female chickens in Africa. The higher slaughter and carcass weights in the semi-scavenging chickens were probably due to the effect of higher digestibility of the broiler finisher feed given to them. The fresh weight of crop contents was 16.7 and 9.14 g/kg biomass for the full-time scavenging and semi-intensively rearing system, respectively. This is in line with the estimates of Olukoi and Sonaiya (2003), who reported that the scavenging feed resources only do not have enough nutrients but also small quantities of scavenging material are available.

The full-time scavenging chickens had about 40% higher fresh crop content weights than semi-intensively kept chickens. This can be attributed to the later chickens being less willing to scavenge vigorously since they are supplemented with commercial feed twice daily. This can also be a result of the nature of the commercial feed; it may have a rapid rate of passage through the crop the smaller the grains of the feed the more easily it bypasses the crop (Feltwell and Fox, 1978). The higher fresh crop content weights in the full-time scavenging chickens can be because of higher body weights than the semi-intensively kept chickens. The higher the live weight the larger the crop and gizzard capacity of the chicken (Dyubele et al., 2010).

The difference in abundance of cereal grains, green forages, insects (worms) and kitchen wastes between the crop contents of birds from the two rearing systems is due to the different feed resource bases of the chicken production systems (Mekonnen et al., 2010). The higher proportion of green forages found in the crop(s) of chickens under full-time scavenging in this study could be attributed to the large consumption of young sprouting shoots which are
abundant in the mid-September to mid-October period. This concurs with Mekkonen et al. (2010) who reported that young sprouting shoots are abundant in the non-harvesting period which is from mid-September to mid-November in this region of South Africa. In general, the scavenging feed resource base could vary with the type of birds due to their foraging behaviour and stage of growth (Rashid et al., 2005).

The cereal grains were higher in crop of the chickens from the full scavenging system as the scavenging feed resource base in most African countries has higher amounts of cereal grains in the dry season than in the rainy season (Goromela et al., 2006). The higher amounts of insects/worms and kitchen waste in the full scavenging rather than the semi-scavenging is not clearly understood.

The dry matter (DM) content of the full scavenging chickens crop contents was 60.1% and the semi scavenging was 69.5% both of which are far higher than that reported by Gunaratne et al. (1993) (34.4%) and Rashid et al. (2004) (45.5-48.9%). However, these results are in agreement with Mekkonen et al. (2010) who also reported higher D.M (91.1- 92.5%) might be due to that the study was conducted mainly in the dry period when cereal grains are in abundance.

The crude protein(CP) content found in this study for full-time scavenging (6.7%) and semi-intensively reared chickens (6.9) respectively, were both lower than the NRC (1994) recommended levels of CP (16% for layers and 14.5% for growers). The crude fibre (CF) content differences found in this study between the two rearing systems is probably because the full scavenging chickens had more access to high fibre content due to the vegetation type in the area unlike the semi-scavenging chickens which had controlled amounts of crude fibre. Overall, the CF content in both systems was lower than what is commercially recommended for commercial layer rations (5%) (Feltwell and Fox, 1978). As the fibre fraction is composed
of cellulose, lignin and hemicellulose that could not be digested efficiently by monogastric-endogenous enzymes, the increase in its level progressively reduces the digestibility of the diet.

The higher levels of Ca and P in the crop contents of semi-scavenging chickens than in the full scavenging kept chickens was probably due to higher quantities of and the bioavailability of the minerals in the commercial broiler finisher mash supplemented to the later chickens. According to McDonald et al. (2002), the minimum phosphorus requirement is 0.5% and calcium levels should be higher for eggshell formation. In the present study the ratio of Ca: P was within the recommended range of these minerals (1:1 to 2:1).

From the present study, the energy (ME) of crop contents in both full-time scavenging and semi-intensively reared local chickens were 12.2 MJ and 12.0 MJ/kg. The higher ME in the full scavenging chickens than in the semi-scavenging chickens was probably due a higher energy content in the cereal grains that were the main scavenging resource for the chickens in the dry season. Both systems had lower ME levels than that recommended by Payne (1990) (10.2 kcal and 9.9MJ/kg DM, respectively). The energy levels found in this study were also in contrast with values obtained in other studies in tropical countries (11.4MJ/kg, 12.1MJ/kg) (Minh et al., 2006). According to Chemjor (1998), energy requirements of Kenyan local chickens during the 14-21 week growth period is 10.1/kg ME.

3.5 Conclusions

The full scavenging system had a feed resource base with a better nutritional value than the semi-scavenging system. Above all, both systems had lower than recommended levels of most nutrients. As these nutrients are critical in the performance of village chickens,
smallholder farmers need to provide feed supplements with known nutritional value and in the correct quantities. Estimating the nutritional value of the scavenging feed resource base of village chickens will allow smallholder farmers to determine which system will provide village chicken meat with meat characteristics desired by the consumers in their marketplaces.
3.6 References


CHAPTER 4
Effect of rearing system on carcass, physical and sensory characteristics of village chicken meat

Abstract

The objective of the study was to determine the effect of full and semi-scavenging production systems on carcass, physical and consumer sensory characteristics of village chickens’ meat. In both systems, 30 chickens from each rearing system were weighed and slaughtered at approximately 24 weeks of age. The post-mortem pH, meat colour and sensory evaluation were determined on the breast muscle. Slaughter and carcass weights were higher (P<0.05) in the semi-scavenging chickens than those of the full scavenging system. Ultimate pH of the breast muscle was significantly (P<0.05) higher in free-ranging chickens than in the semi-scavenging birds. Meat from full scavenging chickens had higher L*, lower a* and lower b* (P<0.05) values than meat from the semi-scavenging chickens. The consumer sensory was done to determine the effect of consumer age, tribe and gender and rearing system on the breast meat’s sensory characteristics. Consumers scored the semi-scavenging chickens’ meat higher (P< 0.05) on initial juiciness, first bite impression and muscle fibre tenderness than the meat from the full scavenging chickens. There were significant (P< 0.05) correlations (0.60) between aroma intensity and overall flavour intensity, first bite impression and muscle fibre tenderness, sustained juiciness and amount of connective tissue and sustained and initial juiciness across rearing systems. The age group 26-30 scored the meat higher (P<0.05) than all other age groups for aroma intensity and typical flavour intensity. Females also scored the meat higher (P<0.05) in atypical flavour (manure-like). The Shona consumers scored higher (P<0.05) than Xhosa, Zulu, Ndebele and other consumers on initial
juiciness and amount of connective tissue. The semi-scavenging chickens had better carcass weights, meat ultimate pH and colour and the best sensory attributes.

**Keywords:** village chicken, meat colour, rearing system, ultimate pH, slaughter weight, juiciness, tenderness
4.1 Introduction

Most rural populations in South Africa consume chicken meat as the cheapest and most available source of protein. According to Sow and Gronget (2010), the increase in food global trade and also the increased involvement of women in business activities are changing the eating habits of populations. Generally in developing countries like South Africa, the urban population prefers imported genetically modified chicken genotypes to local village chickens due to lesser preparation and cooking time. This preference provides a threat to the local chicken meat consumption and consequently the income of resource-poor chicken farmers. Preference of meat trends by consumers tends to be indirectly affected by meat sensory characteristics such as aroma intensity, flavour and juiciness (Chulayo et al., 2011).

The diet of both exotic and indigenous chickens has an effect on the carcass, physicochemical and sensory attributes of village chickens. Different feeding systems result in different nutritional status (Chapter 3) and different performance levels on slaughter live weights, carcass weight, meat physicochemical characteristics and sensory characteristics. Rearing village chickens with full feeding supplements provides chickens with high percentage of breast muscle, which is more tender and of a better quality (Wattanachant, 2008). Meat colour is an important selection criterion used by consumers to purchase meat. Meat colour and ultimate meat pH at 24h post-mortem are positively correlated (Wattanachant, 2008).

According to Tshabalala et al. (2003), meat sensory characteristics, which consumers’ base meat quality on, are a scientific method which measures and analyses the quality of meat as they are perceived by taste senses of flavour, aroma, juiciness and tenderness. In meat sensory characteristic analysis the advantage of using consumers over panellists lie in the fact that consumers are the end users of the meat and they give a real life assessment of meat
quality (Xazela et al., 2011). It is reported that meat sensory characteristics are affected mainly by diet (Wheeler et al., 1996; Andersen et al., 2005), and genotype (King et al., 2006; Muchenje et al. 2008a; Chulayo et al., 2011).

As reported by Sow and Gronget (2010), sensory characteristic analysis allows small-scale village chicken farmers to identify, understand and respond to consumer preferences more efficiently (Owens and Sams, 1998; Lin et al., 2004; Fanatico et al., 2007; Saha et al; 2009). Identifying sensory characteristics in village chicken meat and consumer preferences will assist village chicken meat producers to increase their market competition strengths (Tan et al., 2001; Lawlor et al., 2003; Ponte et al., 2004; Young et al., 2004). Therefore the objective of this study was to compare carcass characteristics, physical and sensory characteristics of village chickens reared under different feeding systems.
4.2 Materials and Methods

4.2.1 Site Description

The birds in this study were raised as described in Chapter 3.

4.2.2 Chicken slaughter and measurements

The birds in this study were slaughtered as described in Chapter 3. The purchased chickens were weighed before and after slaughter and the weights were recorded. The dressing ratios were calculated by dividing the warm carcass weight by the slaughter weight.

4.2.3 pH measurements in breast muscle

A digital, portable pH meter (spear-end) (CRISON Instrument, SA, Spain) was used to measure the pH and temperature of the breast muscle of each individual bird at 4h and 24h post-mortem. In between the two measurements, all carcasses were kept in a refrigerator at -4°C. The pH meter was standardized by a three-point method against buffers of pH 4.0, pH 7.0 and pH 9 standard solutions (CRISON Instruments, SA, Spain) before each sample measurement. The same equipment also measured the meat temperature and it was recorded.

4.2.4 Breast meat colour measurements

At 24h post-mortem, the CIELAB trichromatic colour profile of lightness (L*), redness (a*), and yellowness (b*) was performed on the breast muscle of each individual bird with a colour guide 45/0 BYK-Gardener GubH machine (Analis, Suarlee), with a 20mm diameter measurement lens and illuminant D65-daylight, 10° standard observer. Three readings were taken by rotating the Colour Guide 90° between each measurement in order to obtain an average of the colour. The colour guide was calibrated against a green standard before each sample’s measurement and the skin was removed before each measurement.
4.2.5 Sensory Evaluation by Consumers

The group that was used for consumer meat sensory evaluation of the full-time scavenging and semi-intensively reared chickens consisted of 60 participants. The panellists were students and staff from the University of Fort Hare. The panel consisted of people of different gender, tribes and age. The five tribes were Xhosa, Zulu, Shona, Ndebele and other of the fewer tribe groups. Age was categorized into ≤ 20, 21-25, 26-30 and >30. All the participants were trained on how to complete and score sensory evaluation forms (Appendix 1 and 2). When preparing the meat, it was deboned and the breast cuts were boiled in a standard pot, salt was added to taste and cooking loss was not measured. Samples were labelled F (full scavenging) and S (semi-scavenging) and meat was served on serviettes. After tasting each sample, each consumer was given water to rinse his/her mouth to avoid crossover effects.

An eight point descriptive scale was used to evaluate each sensory attribute with aroma intensity (1= extremely bland to 8= extremely intense), initial impression of juiciness (1= extremely dry to 8= extremely juicy), first bite (1= extremely tough to 8= extremely tender), sustained impression of juiciness (1= extremely dry to 8= extremely juicy), overall tenderness (1= extremely tough to 8= extremely tender), amount of connective tissue (1= extremely abundant to 8= none), Overall flavour intensity (1= extremely bland to 8= extremely intense), a- typical flavour intensity (1= none to 8= extremely intense) and atypical flavour (1=livery/bloody, 2= cooked vegetable, 3= pasture/grassy, 4= animal-like/kraal, 5= metallic, 6= sour and 7= unpleasant).
4.2.6 Statistical analysis

The effect of each type of rearing system on carcass characteristics and physicochemical were analysed. Comparison of means were analysed using Turkey’s Test. Correlation coefficients for pH at 4h and 24h were generated using Pearson’s Correlation coefficient option of SAS ® (SAS, Institute, 2003). General Linear Models (GLM) procedure of SAS (SAS, 2003, Version 6, SAS Institute, Cary, NC, USA) was used to analyse the effects of consumer age, gender, tribe and the type of rearing system on carcass, pHu and colour, meat sensory characteristics of village chickens. The model used is:

\[ Y_{ijkl} = \mu + A_i + G_j + T_k + R_l + E_{ijkl} \]

Where, \( Y_{ijkl} \) is the response variable (aroma intensity, initial impression of juiciness, first bite, sustained impression of juiciness, muscle fibre and tenderness, amount of connective tissue, overall flavour intensity and relevant a-typical flavor); \( \mu \), overall mean common to all observations; \( A_i \), effect of participant age group (21-30, 30-40, 40, >50), \( G_j \), effect of participant gender (male, female), \( T_k \), tribe effect (Xhosa, Shona, Zulu, Ndebele and other), \( R_l \), rearing system effect (full or semi-scavenging). Least Significant difference was used to compare means. Correlations between sensory characteristic scores were determined using the PROC CORR procedure of SAS (2003).

The model for carcass weight, ultimate pH (pHu) and colour (L*, a*, b*) is:

\[ Y_{ij} = \mu + R_i + e_{ij} \]

Where, \( Y_{ij} \) is the meat quality variable (carcass weight, pHu, L*, a*, b*); \( \mu \), is overall mean to all observations; \( R_i \), is effect of rearing system (full or semi-scavenging). Least Significant difference was used to compare means.
Correlations between sensory characteristic scores were determined using the PROC CORR procedure of SAS (2003).

Assumptions made in all models were:

1. The means are normally distributed in a population.

2. The two populations have equal variances.
4.3 Results

4.3.1 Carcass characteristics

The effect of type of rearing system on carcass characteristics (slaughter weight and carcass weight) is presented in Table 4.1. The current study shows significantly (P< 0.05) higher slaughter and carcass weights in chickens from the semi-scavenging system than the full scavenging one. The dressing ratios of the chickens did not differ significantly between the two rearing systems (P> 0.05).
Table 4-1 Least square means (± standard errors) of carcass characteristics of full scavenging and semi-scavenging chickens (n=60)

<table>
<thead>
<tr>
<th>Carcass characteristic</th>
<th>Type of rearing system</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full scavenging</td>
<td>Semi-scavenging</td>
<td></td>
</tr>
<tr>
<td>Slaughter weight (kg)</td>
<td>1.8 (^{a} \pm 0.09)</td>
<td>2.1 (^{b} \pm 0.07)</td>
<td></td>
</tr>
<tr>
<td>Carcass weight (kg)</td>
<td>1.0 (^{a} \pm 0.06)</td>
<td>1.3 (^{b} \pm 0.05)</td>
<td></td>
</tr>
<tr>
<td>Dressing percentage</td>
<td>0.62 (^{a} \pm 0.024)</td>
<td>0.66 (^{a} \pm 0.01)</td>
<td></td>
</tr>
</tbody>
</table>

\(^{ab}\) Values in same row with different superscripts are significantly different at P<0.05
4.3.2  *pH and colour of chicken meat from full and semi-scavenging systems*

The post-mortem pH and meat colour from the full and semi-scavenging systems are presented in Table 4.2. The results show the pH at 4h and the pHu of the full scavenging chickens’ meat was higher than that of the semi-scavenging chickens’ meat. In Table 4.2, meat from the full scavenging birds had significantly (P< 0.05) higher L* values than that of the semi-scavenging chickens. This means that the meat from the full scavengers was paler than that of the semi-scavengers. Full scavenging birds had lower a* values than the semi-scavenging birds (P<0.05). In the present study, there were no significant (P>0.05) differences in b* values between the two systems.
Table 4-2 Means for post-mortem physical characteristics of chicken meat from full and semi-scavenging systems

<table>
<thead>
<tr>
<th>Physicochemical characteristic</th>
<th>Type of rearing system</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full scavenging</td>
<td>Semi-scavenging</td>
<td></td>
</tr>
<tr>
<td>pH- 4hr</td>
<td>6.1&lt;sup&gt;a&lt;/sup&gt; ± 0.04</td>
<td>5.9&lt;sup&gt;b&lt;/sup&gt; ± 0.03</td>
<td></td>
</tr>
<tr>
<td>pHu</td>
<td>6.0&lt;sup&gt;a&lt;/sup&gt; ± 0.03</td>
<td>5.7&lt;sup&gt;b&lt;/sup&gt; ± 0.04</td>
<td></td>
</tr>
<tr>
<td>L*</td>
<td>60.2&lt;sup&gt;a&lt;/sup&gt; ± 1.15</td>
<td>46.9&lt;sup&gt;b&lt;/sup&gt; ± 0.80</td>
<td></td>
</tr>
<tr>
<td>a*</td>
<td>3.8&lt;sup&gt;b&lt;/sup&gt; ± 0.35</td>
<td>7.7&lt;sup&gt;a&lt;/sup&gt; ± 0.42</td>
<td></td>
</tr>
<tr>
<td>b*</td>
<td>15.0&lt;sup&gt;a&lt;/sup&gt; ± 1.29</td>
<td>18.1&lt;sup&gt;a&lt;/sup&gt; ± 0.67</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a,b</sup> Values within the same row with different superscripts are significant (P<0.05)
4.3.3 Correlations between meat colour (\(L^*, \ a^*, \ b^*\)), pH at 4h and pH at 24h.

Correlations between meat colour after 24h and pH (4h and 24h) are presented in Table 4.3. There was a significant (P< 0.001) positive (r= 0.50) relationship between pH at 4h and pH at 24h post-mortem. There was a strong positive (r=0.60) correlation between the \(L^*\) values and pHu. The associations between breast meat temperature at 4h and \(a^*\) values were significant (P<0.001) and positive (0.70). Negative correlations (r= -0.63) were found between \(a^*\) values and pHu post-mortem. Therefore as the ultimate pH decreased, the meat redness increased. There was also a negative relationship between \(L^*\) and \(a^*\) values (r= -0.55).
Table 4-3 Pearson’s correlation coefficients and probabilities of village chicken breast meat lightness (L*), redness (a*) and yellowness (b*) at pH 4h and pH 24h post-mortem.

<table>
<thead>
<tr>
<th></th>
<th>pH 24h</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>Temp⁰ 4h</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH 4h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.51***</td>
<td>0.19</td>
<td>-0.12</td>
<td>-0.21</td>
<td>-0.23</td>
</tr>
<tr>
<td></td>
<td>0.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH 24h</td>
<td>0.60***</td>
<td>-0.63***</td>
<td>-0.34</td>
<td>-0.48</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.001</td>
<td>0.001</td>
<td></td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>L*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.55</td>
<td>-0.02</td>
<td>0.91</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>a*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.19</td>
<td>0.70***</td>
<td>0.19</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>b*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp⁰ 4h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***Significantly correlated at P < 0.05.
Table 4.4 shows the effect of type of rearing system on the meat sensory characteristics and there were no interactions. There were significant differences between the two rearing systems (P<0.05) on initial juiciness, first bite impression, muscle fibre and tenderness and typical flavour intensity. Participants scored higher for these sensory characteristics in the semi-intensively kept chickens. No differences between the full-time scavenging and semi-intensively reared in scores of sensory characteristics such as aroma intensity, sustained juiciness, amount of connective tissue, overall flavour intensity and typical flavour were observed.
Table 4-4 Least square means (± standard errors) of type of rearing system effect on the meat sensory attributes of village chicken

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of rearing system</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full-time scavenging</td>
</tr>
<tr>
<td>Aroma intensity</td>
<td>4.9&lt;sup&gt;a&lt;/sup&gt; ±0.25</td>
</tr>
<tr>
<td>Initial juiciness</td>
<td>3.4&lt;sup&gt;a&lt;/sup&gt; ±0.20</td>
</tr>
<tr>
<td>First bite impression</td>
<td>3.4&lt;sup&gt;a&lt;/sup&gt; ±0.19</td>
</tr>
<tr>
<td>Sustained juiciness</td>
<td>4.0&lt;sup&gt;a&lt;/sup&gt; ±0.19</td>
</tr>
<tr>
<td>Muscle fiber and tenderness</td>
<td>3.8&lt;sup&gt;a&lt;/sup&gt; ±0.21</td>
</tr>
<tr>
<td>Amount of connective tissue</td>
<td>3.7&lt;sup&gt;a&lt;/sup&gt; ±0.17</td>
</tr>
<tr>
<td>Overall flavor intensity</td>
<td>4.5&lt;sup&gt;a&lt;/sup&gt; ±0.24</td>
</tr>
<tr>
<td>Typical flavor intensity</td>
<td>4.9&lt;sup&gt;a&lt;/sup&gt; ±0.20</td>
</tr>
<tr>
<td>Atypical flavor</td>
<td>3.0&lt;sup&gt;a&lt;/sup&gt; ±0.19</td>
</tr>
</tbody>
</table>

<sup>ab</sup> Values within a row with different superscripts are significantly different at P<0.05
The effects of age, tribe and gender on consumers’ sensory characteristics are shown in Tables 4.5, 4.6 and 4.7, respectively. In Table 4.5 the age group 26-30 gave significantly (P<0.05) higher scores for the chicken meat than all the other age groups in aroma intensity, typical flavour intensity and typical flavour. There were no differences (P>0.05) among all ages in the sensory characteristics; initial juiciness, first bite impression, muscle fibre tenderness, amount of connective tissue and overall flavour intensity.
Table 4-5 Least square means (± standard errors) of the effects of age on sensory characteristics of village chicken meat.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>≤ 20</th>
<th>21-25</th>
<th>26-30</th>
<th>&gt;30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aroma Intensity</td>
<td>3.9&lt;sup&gt;a&lt;/sup&gt; ±0.61</td>
<td>4.4&lt;sup&gt;a&lt;/sup&gt; ±0.25</td>
<td>5.6&lt;sup&gt;b&lt;/sup&gt; ±0.40</td>
<td>4.9&lt;sup&gt;a&lt;/sup&gt; ±0.38</td>
</tr>
<tr>
<td>Initial Juiciness</td>
<td>3.7&lt;sup&gt;a&lt;/sup&gt; ±0.51</td>
<td>3.9&lt;sup&gt;a&lt;/sup&gt; ±0.21</td>
<td>3.9&lt;sup&gt;a&lt;/sup&gt; ±0.33</td>
<td>3.9&lt;sup&gt;a&lt;/sup&gt; ±0.32</td>
</tr>
<tr>
<td>First bite impression</td>
<td>4.0&lt;sup&gt;a&lt;/sup&gt; ±0.49</td>
<td>3.8&lt;sup&gt;a&lt;/sup&gt; ±0.20</td>
<td>3.7&lt;sup&gt;a&lt;/sup&gt; ±0.32</td>
<td>3.9&lt;sup&gt;a&lt;/sup&gt; ±0.31</td>
</tr>
<tr>
<td>Sustained juiciness</td>
<td>4.9&lt;sup&gt;a&lt;/sup&gt; ±0.47</td>
<td>4.1&lt;sup&gt;a&lt;/sup&gt; ±0.19</td>
<td>4.5&lt;sup&gt;a&lt;/sup&gt; ±0.32</td>
<td>4.3&lt;sup&gt;a&lt;/sup&gt; ±0.30</td>
</tr>
<tr>
<td>Muscle fiber and tenderness</td>
<td>4.2&lt;sup&gt;a&lt;/sup&gt; ±0.54</td>
<td>4.2&lt;sup&gt;a&lt;/sup&gt; ±0.22</td>
<td>4.0&lt;sup&gt;a&lt;/sup&gt; ±0.36</td>
<td>4.2&lt;sup&gt;a&lt;/sup&gt; ±0.34</td>
</tr>
<tr>
<td>Amount of connective tissue</td>
<td>4.0&lt;sup&gt;a&lt;/sup&gt; ±0.41</td>
<td>3.6&lt;sup&gt;a&lt;/sup&gt; ±0.17</td>
<td>4.1&lt;sup&gt;a&lt;/sup&gt; ±0.27</td>
<td>4.0&lt;sup&gt;a&lt;/sup&gt; ±0.26</td>
</tr>
<tr>
<td>Overall flavor intensity</td>
<td>4.3&lt;sup&gt;a&lt;/sup&gt; ±0.60</td>
<td>4.0&lt;sup&gt;a&lt;/sup&gt; ±0.24</td>
<td>4.8&lt;sup&gt;a&lt;/sup&gt; ±0.40</td>
<td>4.3&lt;sup&gt;a&lt;/sup&gt; ±0.37</td>
</tr>
<tr>
<td>Typical flavor intensity</td>
<td>4.0&lt;sup&gt;a&lt;/sup&gt; ±0.48</td>
<td>4.4&lt;sup&gt;a&lt;/sup&gt; ±0.20</td>
<td>5.5&lt;sup&gt;b&lt;/sup&gt; ±0.32</td>
<td>4.6&lt;sup&gt;a&lt;/sup&gt; ±0.30</td>
</tr>
<tr>
<td>Atypical flavor</td>
<td>3.5&lt;sup&gt;b&lt;/sup&gt; ±0.46</td>
<td>2.6&lt;sup&gt;a&lt;/sup&gt; ±0.19</td>
<td>3.3&lt;sup&gt;b&lt;/sup&gt; ±0.30</td>
<td>2.9&lt;sup&gt;a&lt;/sup&gt; ±0.28</td>
</tr>
</tbody>
</table>

<sup>ab</sup> Values within a row with different superscripts are significantly different at P < 0.05
In Table 4.6, gender had a significant (P< 0.05) effect on the typical flavour of the meat across rearing systems. Female consumers scored higher than male consumers for atypical flavour. There were no differences in gender for aroma intensity, initial juiciness, first bite impression, sustained juiciness, muscle fibre and tenderness, amount of connective tissue, overall flavour intensity and typical flavour intensity.
**Table 4.6** Least square means (± standard errors) of gender effects on the sensory characteristics of village chicken meat.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aroma intensity</td>
<td>4.7&lt;sup&gt;a&lt;/sup&gt; ± 0.23</td>
<td>4.8&lt;sup&gt;a&lt;/sup&gt; ± 0.30</td>
</tr>
<tr>
<td>Initial juiciness</td>
<td>3.9&lt;sup&gt;a&lt;/sup&gt; ± 0.18</td>
<td>3.7&lt;sup&gt;a&lt;/sup&gt; ± 0.24</td>
</tr>
<tr>
<td>First bite impression</td>
<td>3.8&lt;sup&gt;a&lt;/sup&gt; ± 0.18</td>
<td>3.8&lt;sup&gt;a&lt;/sup&gt; ± 0.24</td>
</tr>
<tr>
<td>Sustained juiciness</td>
<td>4.4&lt;sup&gt;a&lt;/sup&gt; ± 0.17</td>
<td>4.2&lt;sup&gt;a&lt;/sup&gt; ± 0.23</td>
</tr>
<tr>
<td>Muscle fiber and tenderness</td>
<td>4.2&lt;sup&gt;a&lt;/sup&gt; ± 0.19</td>
<td>4.0&lt;sup&gt;a&lt;/sup&gt; ± 0.26</td>
</tr>
<tr>
<td>Amount of connective tissue</td>
<td>3.8&lt;sup&gt;a&lt;/sup&gt; ± 0.15</td>
<td>3.8&lt;sup&gt;a&lt;/sup&gt; ± 0.20</td>
</tr>
<tr>
<td>Overall flavor intensity</td>
<td>4.2&lt;sup&gt;a&lt;/sup&gt; ± 0.21</td>
<td>4.2&lt;sup&gt;a&lt;/sup&gt; ± 0.29</td>
</tr>
<tr>
<td>Typical flavor intensity</td>
<td>4.5&lt;sup&gt;a&lt;/sup&gt; ± 0.18</td>
<td>4.9&lt;sup&gt;a&lt;/sup&gt; ± 0.24</td>
</tr>
<tr>
<td>Atypical flavor</td>
<td>2.6&lt;sup&gt;a&lt;/sup&gt; ± 0.17</td>
<td>3.2&lt;sup&gt;b&lt;/sup&gt; ± 0.22</td>
</tr>
</tbody>
</table>

<sup>ab</sup> Values within a row with different superscripts are significantly different at P< 0.05
As shown in Table 4.7, the Shona consumers scored significantly (P<0.05) different compared to the other four tribes on the initial juiciness and amount of connective tissue of the village chicken meat across rearing systems. They gave higher scores for these attributes. There were no differences (P<0.05) observed between tribes on aroma intensity, first bite impression, sustained juiciness, muscle fibre and tenderness, overall flavour intensity, typical flavour intensity, and typical flavour across the two rearing systems.
Table 4.7 Least square means (± standard errors) of tribe effects on the sensory characteristics of village chicken meat.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Tribe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Xhosa</td>
</tr>
<tr>
<td>Aroma intensity</td>
<td>4.4(^a) ±0.25</td>
</tr>
<tr>
<td>Initial juiciness</td>
<td>4.0(^a) ±0.20</td>
</tr>
<tr>
<td>First bite impression</td>
<td>4.1(^a) ±0.20</td>
</tr>
<tr>
<td>Sustained juiciness</td>
<td>4.4(^a) ±0.20</td>
</tr>
<tr>
<td>Muscle fiber and tenderness</td>
<td>4.2(^a) ±0.22</td>
</tr>
<tr>
<td>Amount of connective tissue</td>
<td>4.2(^a) ±0.16</td>
</tr>
<tr>
<td>Overall flavor intensity</td>
<td>4.2(^a) ±0.24</td>
</tr>
<tr>
<td>Typical flavor intensity</td>
<td>4.7(^a) ±0.20</td>
</tr>
<tr>
<td>Atypical flavor</td>
<td>2.8(^a) ±0.19</td>
</tr>
</tbody>
</table>

\(^{ab}\) Values within a row with different superscripts are significantly different at P < 0.05
Correlations between different sensory characteristics are presented in Table 4.8. Aroma intensity was strongly (P< 0.001) correlated to overall flavour intensity. There was a strong (P<0.001) relationship between first bite impression and muscle fibre and tenderness. First bite impression was also correlated (P<0.001) to both sustained juiciness and amount of connective tissue. Initial juiciness had a strong (P<0.001) relationship with sustained juiciness. The former was also correlated to first bite impression and muscle fibre and tenderness. No significant relationships were observed between other sensory attributes across rearing systems.
Table 4-8 Pearson’s correlation coefficients of sensory characteristics across rearing systems of village chickens.

<table>
<thead>
<tr>
<th>Sensory characteristics</th>
<th>A.I</th>
<th>I.J</th>
<th>F.B</th>
<th>S.J</th>
<th>MFT</th>
<th>ACT</th>
<th>OFI</th>
<th>TFI</th>
<th>T.F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.I</td>
<td>0.16</td>
<td>0.43***</td>
<td>0.39***</td>
<td>0.29**</td>
<td>0.23**</td>
<td>0.14</td>
<td>0.27**</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>I.J</td>
<td>0.18</td>
<td>0.49***</td>
<td>0.66***</td>
<td>0.12</td>
<td>0.18*</td>
<td>0.17</td>
<td>0.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F.B</td>
<td>0.04</td>
<td>0.30***</td>
<td>0.38***</td>
<td>0.19*</td>
<td>0.18*</td>
<td>0.07</td>
<td>-0.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.J</td>
<td>0.17</td>
<td>0.12</td>
<td>0.12</td>
<td>0.19*</td>
<td>0.06</td>
<td>-0.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MFT</td>
<td>-0.01</td>
<td>0.24</td>
<td>0.03</td>
<td>0.06</td>
<td>0.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACT</td>
<td>-0.01</td>
<td>0.24</td>
<td>0.03</td>
<td>0.06</td>
<td>0.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OFI</td>
<td>0.46***</td>
<td>0.24**</td>
<td>0.10</td>
<td>0.06</td>
<td>0.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TFI</td>
<td>0.24**</td>
<td>0.10</td>
<td>0.06</td>
<td>0.04</td>
<td>0.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T.F</td>
<td>-0.07</td>
<td>-0.03</td>
<td>-0.25</td>
<td>0.04</td>
<td>0.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AI = Aroma intensity; IJ = initial juiciness; SJ = sustained juiciness; MFT = muscle fibre and overall tenderness; ACT = amount of connective tissue; OFI= overall flavor intensity; TFI=typical flavor intensity; TF= typical flavor. *Significantly correlated at P < 0.05; ** significantly correlated at P < 0.01; *** significantly correlated at P < 0.001.
4.4 Discussion

Semi-scavenging chickens had higher slaughter and carcass weights than their full scavenging counterparts because the semi-scavenging birds were being fed broiler finisher mash and therefore, their growth rates were higher due to the easier digestibility and more nutrient dense commercial feed than feed from scavenged sources. The results of the current study are in agreement with Huque et al. (1999) who stated that supplemental feed, especially protein sources, increased productivity of scavenging and semi-scavenging village chickens. Higher growth rates in semi-scavenging chickens can also be attributed to better bioavailability of crude protein in broiler finisher mash unlike in full scavenging chickens. Better bioavailability results in improved digestibility and utilization by the animal’s metabolic activities. The lower slaughter and carcass weights in fully scavenging chickens is probably a sign of lower growth rates due to low protein feeds during the time when the chickens were slaughtered, that is, the dry season and also the full scavenging chickens used more energy scavenging than their counterparts. (Mekonnen et al., 2010; Kondombo, 2005). This concurs with the findings of many authors who discovered that during the dry season there is a protein deficiency in scavenging feed resources as insects, worms and green forages are unavailable (Huque et al., 1994; Tadele, 1996; Huque, 1999; Mwalusanya et al., 2002; Rashid et al., 2005; Mekkonen et al., 2010).

Meat ultimate pH and colour

The higher ultimate pH of the full scavenging chickens may be as a result of less glycogen reserves in their muscles for glycolysis than the semi-scavenging birds before slaughter (Wattanachant, 2008). The findings of the current study concur with findings of Wattanachant (2008) who reported high meat pH in chickens raised under free-ranging
systems. As stated by Castellini et al. (2002), ultimate pH influences the structure of the myofibrils and therefore colour and water holding capacity of the muscle. This may affect the sensory characteristics of the meat. The differences in lightness (L*), redness (a*) and yellowness (b*) may be attributed to differences in nutrition in the two production systems. The fact that the meat of the full scavenging chickens was paler (higher L*) than the semi-scavenging chickens meat is in agreement with Castellini et al. (2002) who noted that more outdoor access resulted in higher paleness values compared to indoor systems in slow-growing chickens. The birds from the full scavenging system had more access to the outside environment and thus the associated exercise can have an impact on muscle fibres and meat colour. The differences in meat paleness can be attributed to the environmental conditions in the different rearing systems (Fanatico et al., 2007). Providing different feeds to indigenous chickens has effects on the meat colour of village chickens (Fanatico et al., 2005; Wattanachant, 2008). According to Hoffman et al. (2010), the rough nature of transport with difficulty in balancing on trucks during transit to slaughterhouses stresses birds and can also adversely affect meat quality.

The strong relationship between pH 4h and pH 24h post-mortem is a result of the decline in pH from the time of slaughter to when there is post-mortem aging (24h post-mortem). The positive correlation between L* values and pH at 24h means that the higher the pH at 24h the darker the meat, and the lower the pH, the lighter the meat and this is because the meat is classified as dry, firm and dry meat. Not fully understood. This phenomenon contradicts reports by Barbut et al. (2005), who stated that the relationship between ultimate pH (pHu) and L* is strongly negative. High ultimate pH meat is often characterized as being dark, firm and dry (DFD) and the light meat as pale, soft and exudative (PSE) (Wattanachant, 2008). The results of this study are in agreement with Fletcher (1999a, b), who reported that muscle
pH and meat colour are highly correlated. The negative correlation between $a^*$ values and pH at 24h post-mortem is not clearly understood. Although higher values for colour attributes are associated with rapid pH during rigor mortis and this is enhanced by slower temperature decline (Strydom et al., 2010).

The significantly higher scores of initial juiciness first bite impression and muscle fibre tenderness, in the semi-scavenging than the full-scavenging, is in agreement with Xazela et al. (2011). When an animal is given supplementary feed, it accrues more intra-muscular fat than the one that is not. Meat juiciness is directly related to intramuscular lipids and moisture content of meat (Muchenje et al., 2008a). Supplementation using commercially prepared feeds tends to improve tenderness. According to Swan et al. (1998) and Muchenje et al. (2008b), tenderness varies due to changes to the myofibrillar protein structure of muscle in the period between animal slaughter and meat consumption, tenderness also depends on the amount of exercise.

The consumers of the age group 26-30 years gave higher scores for aroma intensity, typical flavour intensity and atypical flavour than all the other age groups because of their experience in tasting village chicken meat. This concurs with reports by Dyubele et al. (2010) and Chulayo et al. (2011) that, the perception of chicken meat is determined by the background of the consumer. Consumers’ sensory reports also agree with Dyubele et al. (2010) and Chulayo et al. (2011) that there were no significant gender effects on chicken meat. The reason for the gender difference noted on typical flavour while there were no differences on other sensory attributes is not fully understood.

The Shona consumers scored significantly lower on initial impression of juiciness and amount of connective tissue and this can be attributed to different cultures in communities.
and that these cultures are influenced by availability of resources, pragmatic practices and beliefs (Webb et al., 2005).

4.4.6 Correlations among sensory characteristics

The positive strong relationship between aroma and overall flavour intensity concurs with findings by Dyubele et al. (2010) and Chulayo et al. (2011), as flavour is a very complex attribute of meat palatability (Calkins and Hodgen, 2007; Muchenje et al., 2010). As aroma intensifies, flavour also intensifies; this is because flavour is a combination of aroma and taste. The composition and amount of fat also determines the intensity of flavour in meat (Muchenje et al., 2010). The high correlations between initial juiciness and sustained juiciness could be a result of intramuscular fat. The findings also concur with Ngambu et al. (2011) who reported intramuscular fat as influencing meat juiciness and flavour. Increase in intramuscular fat is associated with an increase in juiciness (Swan et al., 1997). Therefore fat composition and fatty acid profiling in village chickens should be done as it was not conducted in the current study.

The relationship between first bite impression and muscle fibre tenderness is probably due to that fact that meat tenderness is described by the ease with which the incisor teeth cut through the myofibrillar filaments of muscle. In reports by Chulayo et al. (2011), meat tenderness is determined by the amount of connective tissue (Muchenje et al., 2008a).
4.5 Conclusions

Meat from semi-scavenging chickens had better carcass characteristics, ultimate pH and most meat sensory attributes than from the full scavenging system. Smallholder farmers can rear their village chickens under a semi-scavenging system supplemented by commercial feed without any negative meat quality if commercial feeds are expensive even locally available reliable feeds are good supplements.
4.6 References


CHAPTER 5: General Discussion and Conclusions

5.1 General Discussion

Village chicken production is seriously affected by a lack of adequate scavenging feed resources in terms of both quality and quantity of nutrients. In developing countries such as Bangladesh, Ethiopia, Kenya, Sri Lanka and Tanzania, village chickens do not receive a balanced diet all year round (Tadele, 1996; Mwalusanya et al., 2002; Rashid et al., 2005; Mekkonen et al., 2010; King’ori et al., 2010). It is of major importance to assess the nutritional status of scavenging feed resources in the Eastern Cape Province of South Africa and compare them to the nutrient requirements of village chickens. Knowledge of the nutritional status of the scavenging feed resources in terms of crude protein, crude fibre, calcium %, and phosphorus % will enable resource-poor farmers to identify nutrition gaps and thus provide adequate supplementary feedstuffs. Creating a balanced diet consisting of the correct nutrients in sufficient quantities improves growth rates and carcass (market) weights and meat quality of village chickens, this will positively impact on the livelihoods of the smallholder farmers by increasing income from poultry and nutritional status. Information gathered from the assessment of the nutritional status of the scavenging feed resources of village chicken will also help resource-poor farmers in developing efficient supplementation programmes.

The main idea behind this research was to determine the nutrient status of scavenging feed resources in different production systems and to compare the meat quality characteristics of village chickens from full and semi-scavenging systems. The nutrient status of scavenging feed resources available to village chickens varies with production system, geographic location, climate and season (Mwalusanya et al., 2002; Rashid et al., 2005). Nutrients available to village chickens in the full and semi-scavenging systems, in terms of crude
protein, crude fibre, calcium, phosphorus percentages were assessed in Chapter 3. In Chapter 4, the effect of production system on meat quality was assessed by comparing the carcass, physical and sensory characteristics of chicken meat of the two systems. In Chapter 3 nutritional status of the scavenging feeds resources of the semi-scavenging were better than those of the full scavenging birds. Supplementary feeding in the semi-scavenging system accounted for the higher calcium and phosphorus levels. Levels of crude protein, calcium, phosphorus were low compared to the recommended levels probably because the study was conducted in the dry season, in which crude fibre is higher as a result of cereal grain dominance in the scavenging feed resources.

In Chapter 4, the effect of production system carcass, meat ultimate pH (pHu) and sensory characteristics of village chickens meat was analysed. The higher live and carcass weights of the semi-scavenging chickens were probably due to faster growth rates because of feed supplementation. The higher initial and ultimate pH of meat in full scavenging chickens is because they had more outdoor access thereby resulting in higher pH meat than indoor closure. Ultimate pH is also influenced by glycogen content of muscles for glycolysis (Wattanachant, 2008); probably full scavenging birds had less glycogen due to more rigorous physical activity than semi-scavenging birds. The higher paleness (higher L*) of meat of full scavenging chickens is in agreement with Castellini et al. (2002) who reported that more outdoor access resulted in higher paleness values in slow-growing chickens. There were strong correlations between lightness values (L*) and ultimate pH and this concurs with Fletcher (1999a, b) who reported that ultimate muscle pH is highly correlated to meat colour.

On the consumer sensory characteristics of chicken meat, production system had an effect on initial juiciness and muscle fibre tenderness. The strong positive strong relationship between aroma intensity and overall flavour across rearing systems is because flavour is a complex
attribute of meat palatability (Calkins and Hodgen, 2007; Muchenje et al., 2010). High correlations between initial juiciness and sustained juiciness in both production systems are probably a result of intramuscular fat which depends a lot on the feeding system for village chickens.

### 5.2 Conclusion
The full scavenging system had higher amounts of crude protein, crude fat and crude fibre in the diet than the semi-scavenging system. The semi-scavenging system had higher calcium and phosphorus dietary content which are necessary for muscle growth and development in chickens and hence better carcass weights for markets than the full scavenging chickens. Nutrient quantity and quality was the main constraint in the full scavenging production system and it resulted in lower carcass weights than in the semi-scavenging system. Initial glycogen reserves were a determining factor in the meat ultimate pH. The higher pHu meat from the full scavenging results in a shorter shelf life than the lower meat pHu in the semi-scavenging chickens. Full scavenging chickens had higher L* which is associated with pale, soft and exudative meat whilst there was lower L* in semi-scavenging meat. Type of production system was influential in the overall meat juiciness and meat tenderness of chicken meat. The scavenging and supplementary feed resources, nutrient quality and quantity need to be considered when designing efficient feeding schemes in village chickens production.

### 5.3 Recommendations
In the light of the results of this study, it is recommended that smallholder village chicken farmers should use commercial broiler or locally produced feeds to supplement nutrition of
village chickens as this can provide better performance by these birds. Increased productivity can lead to commercialization of village chickens and improve the income of resource-poor farmers. Government should take steps in improving the productivity of village chickens in the rural areas by subsidizing commercial poultry feeds for easier purchase by smallholder farmers.

Areas that might need further investigations include:

- Quantifying the scavenging feed resource bases available to village chickens in the Eastern Cape.

- Fatty acids profiling of the chicken meat to investigate the influence of feeding system on carcass quality (sensory) of village chickens.

- Investigating the amino acid content of the scavenging feed resources and relate it to the amino acid profiles of village chickens meat.
5.4 References


Appendix 1: Meat sensory evaluation form

Sensory analysis of chicken (Semi-intensively reared)

Age: ≤ 20------, 21-25------, 26-30------, ≥ 30------.

Tribe: Xhosa------, Zulu------, Shona------, Ndebele------, Other------.

Gender: Male------, Female------.

Name:…………………………………..

Date:………………

Please evaluate the following samples of chicken for the designated characteristics.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Rating scale</th>
<th>Cooked (plain)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 Aroma intensity</strong></td>
<td>1= Extremely bland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2= Very bland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3= Fairly bland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4= Slightly bland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5= Slightly intense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6= Fairly intense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7= Very intense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8= Extremely intense</td>
<td></td>
</tr>
<tr>
<td><strong>2 Initial impression of juiciness</strong></td>
<td>1= Extremely dry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2= Very dry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3= Fairly dry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4= Slightly dry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5= Slightly juicy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6= Fairly juicy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7= Very juicy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8= Extremely juicy</td>
<td></td>
</tr>
<tr>
<td><strong>3 First bite</strong></td>
<td>1= Extremely tough</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2= Very tough</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3= Fairly tough</td>
<td></td>
</tr>
<tr>
<td>Score</td>
<td>Description</td>
<td>4= Slightly tough</td>
</tr>
<tr>
<td>-------</td>
<td>--------------------------------------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td></td>
<td>Bite</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Sustained impression of juiciness</td>
<td>1= Extremely dry</td>
</tr>
<tr>
<td></td>
<td>The impression of juiciness that you form as you start chewing</td>
<td>6= Fairly juicy</td>
</tr>
<tr>
<td>5</td>
<td>Muscle fibre &amp; overall tenderness</td>
<td>1= Extremely tough</td>
</tr>
<tr>
<td></td>
<td>Chew sample with a light chewing action</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Amount if connective tissue (Residue)</td>
<td>1= Extremely abundant</td>
</tr>
<tr>
<td>Overall flavour intensity</td>
<td>1= Extremely bland</td>
<td>2= Very bland</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>This is the combination of taste while chewing and swallowing- referring to the typical chicken flavor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A- Typical flavour intensity</th>
<th>1= None</th>
<th>2= Practically none</th>
<th>3= Traces</th>
<th>4= Moderate</th>
<th>5= Slightly intense</th>
<th>6= Fairly intense</th>
<th>7= Very intense</th>
<th>8= Extremely intense</th>
</tr>
</thead>
<tbody>
<tr>
<td>A- Typical flavour intensity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tick relevant a- typical flavour

<table>
<thead>
<tr>
<th>1</th>
<th>Livery/bloody</th>
<th>5</th>
<th>Metallic</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Cooked vegetable</td>
<td>6</td>
<td>Sour</td>
</tr>
<tr>
<td>3</td>
<td>Pasture/grassy</td>
<td>7</td>
<td>Unpleasant</td>
</tr>
<tr>
<td>4</td>
<td>Animal-like/kraal(manure)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8= None
Appendix 2: Meat sensory evaluation form

Sensory analysis of chicken (Full-scavenging)

Age: ≤ 20------, 21-25------, 26-30------, ≥ 30------.

Tribe: Xhosa------, Zulu------, Shona------, Ndebele------, Other------.

Gender: Male------, Female------.

Name:…………………………………..                                    Date:………………

Please evaluate the following samples of chicken for the designated characteristics.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Rating scale</th>
<th>Cooked (plain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Aroma intensity</td>
<td>1= Extremely bland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2= Very bland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3= Fairly bland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4= Slightly bland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5= Slightly intense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6= Fairly intense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7= Very intense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8= Extremely intense</td>
<td></td>
</tr>
<tr>
<td>2 Initial impression of juiciness</td>
<td>1= Extremely dry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2= Very dry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3= Fairly dry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4= Slightly dry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5= Slightly juicy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6= Fairly juicy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7= Very juicy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8= Extremely juicy</td>
<td></td>
</tr>
<tr>
<td>3 First bite</td>
<td>1= Extremely tough</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2= Very tough</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3= Fairly tough</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Sustained impression of juiciness</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Muscle fibre &amp; overall tenderness</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Amount if connective tissue (Residue)</td>
<td></td>
</tr>
</tbody>
</table>

| bite | 4= Slightly tough  
5= Slightly tender  
6= Fairly tender  
7= Very tender  
8= Extremely tender |
|---|---|
| 1= Extremely dry  
2= Very dry  
3= Fairly dry  
4= Slightly dry  
5= Slightly juicy  
6= Fairly juicy  
7= Very juicy  
8= Extremely juicy |
| 1= Extremely tough  
2= Very tough  
3= Fairly tough  
4= Slightly tough  
5= Slightly tender  
6= Fairly tender  
7= Very tender  
8= Extremely tender |
| 1= Extremely abundant  
2= Very abundant  
3= Excessive amount  
4= Moderate  
5= Slight  
6= Traces  
7= Practically none |
<table>
<thead>
<tr>
<th>Overall flavour intensity</th>
<th>1= Extremely bland</th>
<th>2= Very bland</th>
<th>3= Fairly bland</th>
<th>4= Slightly bland</th>
<th>5= Slightly intense</th>
<th>6= Fairly intense</th>
<th>7= Very intense</th>
<th>8= Extremely intense</th>
</tr>
</thead>
<tbody>
<tr>
<td>This is the combination of taste while chewing and swallowing—referring to the typical chicken flavor</td>
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<tr>
<td>A- Typical flavour intensity</td>
<td>1= None</td>
<td>2= Practically none</td>
<td>3= Traces</td>
<td>4= Moderate</td>
<td>5= Slightly intense</td>
<td>6= Fairly intense</td>
<td>7= Very intense</td>
<td>8= Extremely intense</td>
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<tr>
<td>Tick relevant a- typical flavour</td>
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<tr>
<td>1  Livery/bloody</td>
<td>5  Metallic</td>
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<tr>
<td>2  Cooked vegetable</td>
<td>6  Sour</td>
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<td></td>
</tr>
<tr>
<td>3  Pasture/grassy</td>
<td>7  Unpleasant</td>
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</tr>
<tr>
<td>4  Animal-like/kraal(manure)</td>
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</table>