# PHYSIO-CHEMICAL PROPERTIES, MEAT QUALITY AND CONSUMER PREFERENCES OF MEAT FROM POTCHEFSTROOM KOEKOEK AND OVAMBO CHICKEN

**MASTER OF SCIENCE IN AGRICULTURE (ANIMAL PRODUCTION)**

**MOTSEPE R.J.**

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# PHYSIO-CHEMICAL PROPERTIES, MEAT QUALITY AND CONSUMER PREFERENCES OF MEAT FROM POTCHEFSTROOM KOEKOEK AND OVAMBO CHICKEN

**BY**

**MOTSEPE RAMOKONE JOHANNA**

**BSC IN AGRICULTURE, ANIMAL PRODUCTION (UL)**

**A DISSERTATION SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF AGRICULTURAL MANAGEMENT (ANIMAL PRODUCTION) DEPARTMENT OF AGRICULTURAL ECONOMICS AND ANIMAL PRODUCTION, SCHOOL OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES, FACULTY OF SCIENCE AND AGRICULTURE, UNIVERSITY OF LIMPOPO, SOUTH AFRICA**

**SUPERVISOR: PROFESSOR D. NORRIS**

**CO-SUPERVISOR: MS M MABELEBELE**

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## DECLARATION

I declare that the dissertation hereby submitted to the University of Limpopo for the Degree of Master of Agricultural Management (Animal Production) has not previously been submitted by me for a degree at this or any other University, that it is my own work in design and execution, and that all material contained therein has been duly acknowledged.

Signature……………………………………….

Motsepe Ramokone Johanna

Date………………......................

## ACKNOWLEDGEMENTS

Firstly I would like to acknowledge the Almighty for the gift of life, and for continuing to strengthen my soul in order to progress.

My special gratitude goes to my supervisor, Prof D. Norris who took me from nowhere, from nobody to somebody, and stood with me even when I showed no sign of being serious and committed. He really cared and would patiently give me attention until I knew what was expected of me. I am also indebted to my co-supervisor, Monnye Mabelebele, who from time to time was on my side to see that the work is done properly, and always insisting that whatever I was doing should be "SMART" and perfect.

Special thanks also goes to my family for moral support they gave. My daughter during battlefield of the mind would take some of the responsibilities to lighten up the heavy load. My husband who was assisting financially though wondering if ever I could make it and my sons were always there, asking how I felt to be a student at my age.

# DEDICATION

This good work is dedicated to my late grandfather, Lesiba Seth Paul Digashu. He was not educated but was reading and always told me that information is galore but hiding in black and white.

**ABSTRACT**

A total of 320 male and female day old Ovambo and Potchefstroom koekoek (PK) chickens, were randomly assigned to a 2 (breed) × 2 (sex) factorial arrangement in a completely randomised design. Meat quality traits of male and female Ovambo and Potchefstroom Koekoek chickens were evaluated in this comparative study. The chickens were raised from day-old and fed on a commercial grower diet with 11.5 MJ/ME kg DM and 20% crude protein. The carcass traits of the Ovambo and Potchefstroom Koekoek (PK) were similar (P>0.05) except for breast yield. Sex affected on all carcass traits. Breed, sex, and time interactions influenced colour parameters of thigh and drumstick meat except redness (a*) and yellowness (b*) values of chicken breast meat. The pH varied significantly (P<0.05) between the breeds, sex and time period. The sensory evaluations of the chicken breeds were similar (P>0.05). However, tenderness of the breast meat as measured by shear force was higher for PK than that of Ovambo chickens. Fatty acid profiles of the chickens were not affected (P>0.05) by breed or sex. The ratios of n-6 and n-3 fatty acids were significantly lower in both breeds which are desirable in reducing the risk of many heart-related diseases. The information obtained from this study can assist efforts to promote production of indigenous chickens. The information also sheds some light in terms of consumer awareness for healthier meat choices.

Keywords: Breed, Carcass traits, Meat colour, meat pH, Fatty acids

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| a* | :redness |
| b* | :yellowness |
| F | :Female |
| G | :Grams |
| GCA | :General combining ability |
| GLM | :General Linear Model |
| L* | :Lightness |
| LSD | :Least Significance Difference |
| M | :Male |
| ME | :Maternal effects |
| KG | :Kilogram |
| O | :Ovambo |
| PK | :Potchefstroom Koekoek |
| pH24h | :pH at 24 hours post-moterm |
| pH2h | :pH at 2 hours post-moterm |
| pHu | :Ultimate pH |
| SAS | :Statistical Analysis Software |
| SCA | :Specific combining ability |
| SE | :Standard error |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background

The purpose of indigenous chickens to a rural farmer is mainly for supplying eggs and meat to the household's consumption and to a lesser extent, income from sales of these produce (Tadelle *et al*., 2003; Norris and Ngambi, 2006). Indigenous chicken meat and eggs are significant food products that enhance the nutritional needs of malnourished children across rural Africa (Bett *et al*., 2013), and they are affordable to most of the rural households. Their accessibility and availability in rural areas not only play a role in poverty alleviation (Pica-Ciamarra and Dhawan, 2010) but also their consumption is associated with less diet related health diseases (Wattanachant, 2005).

Appearance, texture and composition contribute to the overall consumer acceptability of poultry and other meat products (Packard, 2014). Meat colour is one of the primary characteristic that most consumers notice when deciding whether or not to buy a meat product (Fanatico *et al*., 2007). Consumers tend to reject the products if the colour varies from the expected norm (Qiao *et al*., 2001). pH values of chicken meat are also of paramount importance to meat quality as it influences the structure of myofibrils and, in turn, the colour of the meat (Dyubele *et al*., 2010). Wattanachant *et al*. (2004) showed that the muscles of Thai indigenous chickens had a firmer texture and a higher protein content but lower fat and ash contents when compared to conventional broilers. Meat from poultry tends to vary in composition between lines as well as between muscle types. Nutritional concern about dietary fat, particularly saturated fatty acids (SFA) has instigated the production of leaner meats in chicken (Jaturasitha, 2008) and this influences willingness of the poultry consumers to pay for these products (Wattanachant, 2005).

### 1.2. Problem Statement

The demand for indigenous chickens has been increasing for the past 20 years due to its intense flavour and firmness of meat (Pavlovski *et al*., 2013). Consumers have become conscious of their dietary fatty acid intake (especially saturated fatty acids). Scientific evidence has shown a significant relationship between the total intake and composition of dietary fat and a number of health issues such as coronary heart disease and diabetes (Ayerza *et al*., 2002). ‘Modern’ diets are deficient in omega-3 (n-3) fatty acids, and have excessive amounts of omega-6 (n-6) fatty acids. According to Jaturasitha *et al.* (2008), white meat such as chicken meat is considered superior in health as opposed to red meat due to low fat contents, cholesterol and iron. It has been documented that genotype (breed, sex and strain) play a major role in carcass fatness (DeSmet *et al*., 2004; Jaturasitha *et al*., 2004; Shahin and Elazeem, 2005). These genetic factors also influence the quality of meat produced. Unfortunately, the knowledge of these factors in South Africa indigenous chicken lines is limited.

### 1.3 Motivation

Meat quality is one of the economically important traits in chicken. According to Mekchay *et al*. (2010), the major determinants of meat quality consist of toughness, tenderness, juiciness and flavour. Guan *et al*. (2013) identified other factors that affect meat quality, such as, genetics, nutrition and environment. Castellini *et al*. (2008) reiterated that poultry meat quality is affected by genotype, diet, age at slaughter and motor activity of birds, and their adaptation for outdoor production. These factors integrate to give an overall assessment of meat quality by the consumer. Meat quality traits of poultry include chemical (proteins, total lipids etc.)

and physical traits (pH, colour, water holding capacity, texture, sarcomere length etc.) (Petracci and Baeza, 2011). Poultry consumers often prefer indigenous chicken breeds over commercial breeds due to their meat qualities (Sheng *et al*., 2013). There is an increasing demand for natural meat that has been produced without the use of additives and chemicals, hence, the relevance of indigenous chickens, which can be produced without any supplementary feeding, has increased greatly (Muchenje *et al*., 2008a).

According to Muchenje *et al*. (2008b), acceptance of meat is based on several characteristics, such as its sensory characteristics, its nutritional value and its impact on health. Sensory assessments of is influenced by several factors. For example, Barbut (2001) and Fletcher (2002) established that meat colour, method of processing, exposure to chemicals, method of storage and method of cooking are all factors that influence sensory characteristics. Understanding of these factors that affect carcass characteristics and the quality of chicken meat is important in promoting indigenous chicken production.

### 1.4 Objectives

The objectives of the study were to:

1) Compare carcass traits (carcass weight, dressing percentage, pH, meat colour, shear force) of male and female South African Potchefstroom Koekoek and Ovambo chickens.
2) Determine the fatty acid profile of male and female South African Potchefstroom Koekoek and Ovambo chickens.
3) Assess the sensory attributes of male and female South African Potchefstroom Koekoek and Ovambo chickens.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

Poultry production contributes more than 30% of all animal protein consumption in the world (Permin *et al*., 2000). According to Rosegrant *et al*. (2001), poultry will account for more than 40% of the global increase in demand for meat in 2020. This figure is expected to be higher in the communal areas where indigenous chickens accounts for more than 80% of poultry production (Guéye, 2003). Indigenous chickens are increasingly popular in rural areas throughout Africa and Asia. They are economically, nutritionally and culturally important in many countries (Norris and Ng'ambi, 2006). Indigenous chickens are kept for meat and eggs. Their meat and eggs are preferred over those of exotic chickens (Roberts, 1999). According to Wattanachant *et al.* (2004), indigenous chicken meat has a unique taste and texture and is regarded as a delicacy. The selling price of the meat is two or three times higher than that of commercial broilers. Guéye (2003) observed that village producers keep between 5 to 20 birds per household. These chickens contribute to the nutrition and income of the impoverished people in rural areas, particularly, women (Dwinger, 2001). They are generally raised on a free-range system of management where they thrive as scavengers. Almost every household and the poorest social strata keep this flock due to its low cost of production, and they contribute immensely to household food security (Besbes, 2009). These chickens are well adapted to harsh environmental conditions, such as extreme temperature, heavy rain and feed shortages (Gueye, 1998). Most of the rural farmers and village households in South Africa keep chickens under extensive or semi-intensive system of management with little or no input in terms of feed and shelter (Grobbelaar *et al*., 2010). Some subsistence farmers keep these chickens for household production (meat and eggs) while others keep them to supplement their income.

Several indigenous chicken breeds have been identified in South Africa such as Potchefstroom Koekoek, Venda, Naked Neck, and Ovambo to name a few (Grobbelaar *et al*., 2010). Previous research has focused on the characterization of indigenous chicken breeds against commercial broilers in terms of meat quality (Grobbelaar *et al*., 2010). Indigenous chickens generally have a slower growth rate than commercial broilers, which may contribute to differences in their meat properties (Grobbelaar *et al.,* 2010). However, information on the production potential of traits such as meat quality of different indigenous chickens in South Africa is limited and inconclusive. It is, therefore, important to evaluate and compare meat from indigenous chicken lines under intensive management systems.

### 2.2 Indigenous Breeds Used in Communal Production System of South Africa

Sonaiya (2003) described indigenous chickens as involving genetic stock, improved or unimproved, that was raised extensively or semi-intensively in relatively small numbers (usually less than 100 at a time). These chickens are left to scavenge or free range for feed. They are more disease resistant (Minga *et al.,* 2004), capable of utilizing low quality feed (Farrell *et al.,* 2000) and have greater capacity for survival than the commercial hybrid strains (Sonaiya *et al*., 2003). A general description of these birds is inevitable.

### 2.2.1 Potchefstroom Koekoek

Potchefstroom Koekoek was bred at the Potchefstroom Agricultural College during the 1950s (Fourie and Grobbelaar, 2003). The Potchefstroom Koekoek was bred locally from crosses between the black Australorp and the White Leghorn. The term "Koekoek" described the colour pattern of the birds. The feather colouring is sex-linked, making it very useful in breeding programs. If a black or red cock is crossed with a Koekoek hen, the sexes of the offspring can be separated when the chicks are only a day old. Females are completely black, while the males have a white spot on the head. Potchefstroom Koekoek hens lay a brown shelled egg with an average weight of 55.7g and the carcass is attractive with a deep yellow coloured skin (Grobbelaar *et al.,* 2010). Potchefstroom Koekoek cocks and culled hens are used for meat production. The meat of this breed is well-liked among local communities and is preferred to that of the commercial broiler hybrids (Grobbelaar *et al.,* 2010). This breed is popular among rural farmers in South Africa and neighbouring countries for egg and meat production (Grobbelaar, 2008).

### 2.2.2 Ovambo

Ovambo chickens originated from Namibia and Ovamboland (Fourie and Grobbelaar 2003). This breed is dark in colour and small in size. These attributes help the bird to camouflage and protect it from predators. The breed is aggressive and agile (Fourie and Grobbelaar, 2003). It catches and eats mice and young rats.

## 2.3 Roles of Indigenous Chicken in South Africa

Indigenous chicken production is increasingly popular amongst the poor rural communities in South Africa. These chickens play many socio-economic roles in traditional, religious and other customs, such as, gift payments and serve as an important source of protein (McAinsh *et al*., 2004). They are also considered to be the main source of income for the impoverished rural farmers (Swatson *et al*., 2001). Relative to other livestock species, indigenous chicken production has the advantages of having quick returns and relatively simple management practices with numerous market outlets for products (King'ori *et al.,* 2010). These chickens are now a common feature in many households in Africa and have attracted attention in recent years (Aboe *et al.,* 2006). The general perception has grown positively towards the keeping of these flocks as they require low start-up capital and have low maintenance costs (Alabi, 2013). More people in the villages are now engaged in the rearing of these birds, particularly women (Dwinger, 2001). Extensive chicken production generates employment for the rural dwellers and empowers the youth and the less-privileged in the communal areas. South African indigenous chickens are considered valuable genetic resources (Mtileni *et al.*, 2009). Consumers of poultry products prefer indigenous chickens due to nutritional and health reasons (Packard, 2014). Information on the meat quality and carcass characteristics of South African native chicken lines is indispensable to promote their production.

### 2.4 Measures of Meat Quality

Meat quality describes the properties and perceptions of meat (Maltin *et al.,* 2003). It includes attributes such as carcass composition and conformation, the eating quality of meat and health issues associated with meat. Meat quality is one of the economically important traits in chicken. The major determinants of meat quality consist of toughness, tenderness, juiciness and flavour (Mekchay *et al.,* 2010). Guan *et al*. (2013) identified factors that affect meat quality, such as, genetics, nutrition and environment. Castellini *et al.* (2008) also states that poultry meat quality is affected by age at slaughter and motor activity of birds, and their adaptation for outdoor production. These factors integrate to give an overall assessment of meat quality by the consumer. Meat quality traits of poultry include chemical (proteins, total lipids etc.) and physical traits (pH, colour, water holding capacity, texture, sarcomere length etc.) (Petracci and Baeza, 2011). Poultry consumers often prefer indigenous chicken breeds over commercial breeds due to their meat qualities (Sheng *et al.,* 2013). There is an increasing demand for natural meat that has been produced without the use of additives and chemicals (William and Losa 2001), hence, the relevance of indigenous chickens, which can be produced with minimal supplementary feeding.

According to Muchenje *et al*. (2008b), acceptance of meat is based on several characteristics, such as its sensory characteristics, its nutritional value and its impact on health. Chicken meat is better than red meat due to low levels of fat, cholesterol and high levels of iron (Jaturasitha *et al.,* 2008). Sensory assessments of meat are influenced by several factors. For example, Barbut (2001) and Fletcher (2002) established that meat colour, method of processing, exposure to chemicals, method of storage and method of cooking influence sensory characteristics.

### 2.4.1 Sensory Evaluation

Ruan and Xianyi (2004) reported that sensory evaluation is perceived by the senses of sight, smell, taste, touch and hearing. Sensory evaluation is one of the oldest means of quality control and is an essential part of the assessment of food quality (Neumann and Arnold, 1990; Pokorny, 1993). Trained taste panels or consumers can participate in sensory evaluation. Wattanachant (2008) identified five main characteristics that contribute to the overall eating quality of meat. These are taste, texture, juiciness, appearance and odour. However, texture is considered an important attribute by an average consumer (Dransfield, 1994). Meat tenderness and juiciness contribute to different meat textures (Wattanachant, 2008) and they are the most important sensory characteristics that determine meat quality (Sañudo *et al.,* 1996; Tshabalala *et al.,* 2003). The more tender the meat, the more rapidly juices are released by chewing and the fewer residues remain in the mouth after chewing (Muchenje *et al.,* 2008). Wattanachant (2008) observed that the tenderness of meat is the sum total of the mechanical strength of skeletal muscle tissue and it's weakening during the post-mortem ageing of meat. The major factor responsible for postmortem improvement in meat tenderness is degradation of muscle proteins (Wattanachant, 2008). Maltin *et al*. (2003) further stated that postmortem events are the main determinants of tenderness. Sensory analysis allows producers to identify, understand, and respond to consumer preferences more efficiently (Fanatico *et al*., 2007). The other factor that influences the sensory evaluation of meat is genotype (Dyubele *et al.,* 2010). There is limited data available on the sensory evaluation of South African domestic chicken lines.

### 2.4.2 Physical Characteristics

There is limited information on the meat quality and the physical characteristics of indigenous poultry (Van Marle-Köster and Webb, 2000; Sandercock *et al.,* 2009).

#### 2.4.2.1 Colour

Colour is one of the first traits noticed by consumers (Owens *et al.,* 2000; Woelfel *et al.,* 2002). According to Flechter (1999a), the colour of raw poultry meat is critical for consumer selection whereas the colour of the cooked meat is critical for final evaluation. Meat and skin colour are influenced by various factors such as haeme pigments, feeding and genetics (Fletcher, 1999a; Xiong *et al.,* 1999). Guan *et al.*

(2013) stated that assessing meat quality by its colour is difficult due to differences in genotype. Gordon and Charles (2002) found that slow-growing birds have a redder meat colour than fast growing birds due to age effect, while Fanatico *et al.* (2007) reported that the meat of slow-growing birds have less red colouration than the fast-growing birds. The physical appearance of meat is important to the consumers as this informs their choice of purchase. There are a number of factors that affect the physical appearance of meat, such as, genetics, ante- and post-mortem conditions, muscle chemistry and a number of factors related to meat processing and packaging (Mancini and Hunt, 2005). Other major contributing factors to poultry meat colour are myoglobin content, the chemical state, reactions of the myoglobin and meat pH.

2.4.2.2 Meat pH

Meat pH is primarily related to the biochemical state of the muscle at time of slaughter, following the development of rigor mortis (Wattanachant, 2008). Fletcher (1995) observed that muscle pH and meat colour is highly correlated. As mentioned by Fletcher (1999a, b), higher muscle pH is associated with darker meat whereas lower muscle pH values are associated with lighter meat. It has been observed that high pH meat is often characterized as being Dark, Firm and Dry (DFD) and the lighter meat as being Pale, Soft and Exudative (PSE) (Wattanachant 2008). The effect of pH on meat colour is complex. Wattanachant, (2008) reviewed that muscle pH affects the water binding nature of the proteins and therefore directly affects the physical structure of meat and its light reflecting properties. pH influences the structure of myofibrils, and consequently the water holding capacity and colour of meat (Castellini *et al.,* 2002). There are limited reports on the correlation between muscle pH and meat colour of indigenous chicken strains.

#### 2.4.2.3 Shear Force

Shear force is used to access meat tenderness, and higher shear force means tougher meat quality (Cavitt *et al*., 2004). Differences in muscle fibre size affect the shear force property of meat. Mahon (1999) reported that fast-growing lines of chickens have longer fibre diameters than slow-growing lines and longer fibre diameters are often associated with higher shear force and meat toughening. Tang *et al.* (2009) explained that the difference in shear force may be due to age of birds.

## 2.5 Chemical Composition of Meat

In recent years, consumers of poultry products are concerned with the quality of poultry meat. Many consumers are afraid of health-related problems due to high content of fat in meat and adipose tissue in the carcass (Okruszek, 2012). Improving food quality and nutritional value is important for modern nutritionists in their efforts to assist not only to feed an ever-increasing human population but also to enhance health and longevity (Qi *et al*., 2010).

The ultimate goal of the meat industry is to produce meat which meets the dietary recommendations for a reduced intake of fats and cholesterol in the human diet and an optimal ratio of saturated (SFAs), monounsaturated (MUFAs) and polyunsaturated (PUFAs) fatty acids (EFSA, 2010). Among the PUFAs, great attention is paid to *n*-3 fatty acids, especially long-chain *n*-s eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) respectively, which have several benefits for human health, and conjugated linoleic acid which have exhibited anti-carcinogenic and anti-atherogenic properties in animal studies and favourably modulate immune function in humans (McAfee *et al.,* 2010).

### 2.5.1 Fatty Acid Composition of Poultry Meat

Fatty acids play important metabolic, structural and functional roles in physiology (Mennicken *et al*., 2005). From the consumer point of view, meat has often been criticized as a food that is high in fat and that has an undesirable balance of fatty acids (Wood and Enser, 1997). The World Health Organization (WHO, 1990) recommends that a daily consumption of fat should amount up to 30% of all daily energy, out of which only 10% should pertain to saturated fatty acids (SFA). Some fatty acids are essential because they are necessary for vital functions but cannot be synthesized by the human body, such as, the ω-6 and ω-3 families (Harwood, 1995). A daily consumption of 3-7% of poly-unsaturated fatty acids (PUFA) is also advisable, since the linoleic (18:2, ω-6) and α-linolenic (18:3, ω-3) acids are essential fatty acids (EFA). Consumption of larger quantities of PUFA (above 7%) is not recommended, since the free radicals of PUFA can increase the risk of cancer (Polak *et al*., 2002). High intake of SFA also causes elevated plasma cholesterol, which contributes to cardiovascular disease (Bronte-Stewart *et al.,* 1956).

The fatty acid composition of poultry can essentially be influenced by environmental factors, such as diet (Ajuyah *et al.,* 1991), and by genetic factors, such as breed and sex (DeSmet *et al.,* 2004). Wattanachant *et al.* (2004) reported that indigenous Thai chicken muscles (pectoralis and biceps femoris) contained a higher percentage of saturated fatty acids and a lower percentage of polyunsaturated fatty acids. Thai chicken meat was characterized by relatively low C18:1 trans fatty acids and high proportions of individual and total n-3 fatty acids and had a favourable n-6/n-3 fatty acid ratio. Castellini *et al*. (2002) found that the breast and thigh muscles of the organically reared chickens had a higher fraction of SFA and lower MUFA. Fatty acid composition of poultry can be changed through modified feeding strategies (Ajuyah *et al.,* 1991; Chanmugan *et al*., 1992; Scaife *et al.,* 1994). The effects of genetic factors have received less attention (LoFiego *et al*., 2005). Breed related differences in fatty acid composition have been reported in ruminants (Webb and Casey, 1995). However, very few studies have focused on the fatty acid profile of native chicken lines in South Africa. The broad objective of the study is, therefore, to determine the carcass characteristics and the quality of meat from Potchefstroom Koekoek and Ovambo chicken lines.

# CHAPTER 3

# MATERIALS AND METHODS

### 3.1. Birds, House Management and Diets

The study was conducted at the Animal Unit of the University of Limpopo, South Africa. The ambient temperatures around the study area ranged between 20 and 36 °C during summer and between 10 and 25 °C in winter. University of Limpopo lies at latitude 23.880870 and longitude 29.739465 and receives a mean annual rainfall of less than 400 mm (Kutu and Asiwe, 2010). A total of 320 male and female day old Ovambo and Potchefstroom Koekoek (PK) chickens, obtained from the University of Limpopo Hatchery were randomly assigned to a 2 (breed) × 2 (sex) factorial arrangement in a completely randomised design. Chickens were kept in housing unit where natural ventilation and temperature were used. Each pen was equipped with a drinker and a feeder, with deep litter (6cm wood shavings) which were changed whenever wet. Day old chicks were kept in a brooder in the same housing unit where infrared lights were used as heat. After 21 days, chicks were transferred to pens, and at 13 weeks, chickens were transferred to floor house systems. The dietary energy and protein were formulated according to the recommendations of Magala *et al.* (2012) (Table 3.1). Feed and water were supplied *ad libitum*. The experiment was approved by the Animal Ethics Committee of the University of Limpopo (UL), South Africa. All management and procedures in the study were carried out in strict accordance with the requirements of the UL Code of Practice for Experimental Animals and the South African Code of Practice for the Care and Use of Animals for Scientific Purposes.

**Table 3.1** Ingredients and nutrient composition of diets fed to indigenous chickens

| Ingredients (%) | Grower |
|---|---|
| Maize | 69 |
| Soyabean meal | 27 |
| Mineral and vitamin premix | 4 |
| **Nutrient composition of the diet** | |
| Energy (Kcal ME/kg) | 2930 |
| Crude protein % | 20% |
| Fat % | 3.10 |
| Crude fibre | 4.70 |
| Ash % | 8.40 |
| Methionine % | 0.45 |

## 3.2 Slaughter and Meat Sample Collection

Sixty birds (30 males and 30 females from each breed), were weighed and sacrificed to measure parts yield weight at 18 weeks of age. The chickens were randomly chosen, weighed and killed by dislocation of the neck to prevent loss of blood. The birds were eviscerated and the head, neck and feet were cut off to provide a dressed weight. The carcass was subsequently weighed, followed by removal and weighing of breast, thighs and drumsticks, all bone-in with skin. The carcasses from other replicates were then stored at 4 ºC for 24 hours and the chilled carcass weight (CCW) recorded. Dressing percentage was calculated as proportion of carcass weight to body weight of each bird.

### 3.3 pH and Colour Measurements

Muscle pH of the breast, drumstick and thigh was measured at 30 minutes, 24 and 48 hr post-mortem. Muscle pH was measured using a calibrated (standard buffers at pH 4.0 and 7.0) Crison 506 portable pH meter. Meat colour of breast, drumstick and thigh was measured at 30 minutes, 24 and 48 h post-mortem (L*, a* and b* values determined with L* indicating lightness, a* the red-green range and b* the blue-yellow range) was measured using a colour guide 45°/0° colorimeter (catalogue no: 6805; BYK-Gardner, USA). Three measurements per meat portion (breast, thigh, and drumstick) were recorded for both pH and colour.

### 3.4 Shear Force Determination

Breast fillets were cooked on racks in aluminium-lined, covered pans in a preheated convection oven to an internal temperature of 76 °C for 10 min. The Meullenet-Owens razor shear (MORS) method was used to evaluate the shear force of the cooked breast fillets. Shear force was determined on intact fillets using a texture analyzer (TA-XT2i; Scarsdale, NY, USA) and using a razor blade (24 mm in height and 8.9 mm in width) with a 5-kg load cell set to 20-mm penetration depth. Crosshead speed was triggered by a 10-g of contact force with 5 mm/s. Breasts were punctured across muscle fibres (Fanatico *et al.,* 2007).

### 3.5 Consumer Acceptance of Indigenous Chicken Meat

A total of 50 participants were used for consumer sensory evaluation of indigenous chicken meat. The participants were students and staff from the University of Limpopo, composed of different gender and tribes (Venda, Tsonga, SiSwati, Tswana and Pedi speaking persons, which are dominant in the University of Limpopo). An evaluation form scoring the sensory characteristics of each sample was given to each participant and recording of scores was explained. A five scale point descriptive scales were used as described below for taste, flavour, aroma, juiciness, tenderness and overall acceptability: 1=dislike extremely, 2=dislike, 3=neither like nor dislike, 4=like and 5=like extremely.

### 3.6 Fatty Acid Profile

Total lipid from muscle sample was quantitatively extracted, according to of Folch *et al.* (1957), using chloroform and methanol in a ratio of 2:1. An antioxidant, butylated hydroxytoluene was added at a concentration of 0.001 % to the chloroform: methanol mixture. A rotary evaporator was used to dry the fat extracts under vacuum and the extracts were dried overnight in a vacuum oven at 50°C, using phosphorus pentoxide as moisture adsorbent. Total extractable intramuscular fat was determined gravimetrically from the extracted fat and expressed as % fat (w/w) per 100 g tissue. The Fat Free Dry Matter (FFDM) content was determined by weighing the residue on a pre-weighed filter paper, used for Folch extraction, after drying. By determining the difference in weight, the FFDM could be expressed as % FFDM (w/w) per 100 g tissue. The moisture content of the muscle and BF was determined by subtraction (100% - % lipid - % FFDM) and expressed as % moisture (w/w) per 100 g tissue. The extracted fat from feed and muscle was stored in a polytop (glass vial, with push-in top) under a blanket of nitrogen and frozen at –20°C pending fatty acid analyses.

A lipid aliquot (20 mg) of feed, subcutaneous and muscle lipid was transferred into a Teflon-lined screw-top test tube by means of a disposable glass pasteur pipette. Fatty acids were transesterified to form methyl esters using 0.5 N NaOH in methanol and 14 % boron trifluoride in methanol (Park and Goins, 1994). Fatty acid methyl esters (FAMEs) from subcutaneous fat, feed and muscle were quantified using a Varian 430 flame ionization GC, with a fused silica capillary column, Chrompack CPSIL 88 (100 m length, 0.25 mm ID, 0.2 μm film thicknesses). Analysis was performed using an initial isothermic period (40°C for 2 minutes). Thereafter, temperature was increased at a rate of 4°C/minute to 230°C. Finally an isothermic period of 230°C for 10 minutes followed. FAMEs n-hexane (1μl) were injected into the column using a Varian CP 8400 Autosampler. The injection port and detector were both maintained at 250°C. Hydrogen, at 45 psi, functioned as the carrier gas, while nitrogen was employed as the makeup gas. Galaxy Chromatography Software recorded the chromatograms.

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

### 3.7 Statistical Analyses

The effects of breed and sex were analysed using the General Linear Models (GLM) procedure of SAS (SAS, 2010). Where there were no significant interactions between the main factors, interactions were removed from the model. Significant differences in mean values were determined by Tukey's test ($p$ <0.05).

# CHAPTER 4

# RESULTS

## 4.1 Carcass Yield

Breed differences had no effect (*p* >0.05) on carcass yield of PK and Ovambo chickens (Table 4.1). However, body weight, chilled and non-chilled carcass weights, dressing percentage, breast yield, wing and drumstick weights of males from both breeds were higher (*p* <0.05) than in female indigenous chickens. The thigh weights of the female breeds were heavier (*p* <0.05) than their male counterparts.

**Table 4.1** Genotype and sex differences on carcass characteristics of indigenous chickens

| Carcass traits | Genotype | | | | Sex | | | |
|---|---|---|---|---|---|---|---|---|
| | Ovambo | PK | SE | P-value | Female | Male | SE | p-value |
| BW | 1903.2 | 1929.0 | 70.97 | 0.7996 | 1624.5[b] | 2207.7[a] | 70.97 | <.0001 |
| HCW | 1303.4 | 1281.5 | 44.41 | 0.7387 | 1052.3[b] | 1532.7[a] | 44.41 | <.0001 |
| CCW | 1289.1 | 1263.5 | 44.61 | 0.6882 | 1042.5[b] | 1510.1[a] | 44.61 | <.0001 |
| Dressing % | 67.6 | 65.3 | 1.29 | 0.2065 | 64.2[b] | 68.7[a] | 1.29 | 0.0225 |
| Breast yield | 289.8 | 271.6 | 7.24 | 0.0860 | 254.4[b] | 306.9[a] | 7.24 | <.0001 |
| Thigh | 216.8 | 219.5 | 5.12 | 0.7093 | 32.1[a] | 23.7[b] | 5.12 | <.0001 |

[a,b] Means within rows with different superscripts differ significantly at p<0.05.
SE: Standard error
PK: Potchefstroom Koekoek. BW: Body weight. HCW: Hot carcass weight. CCW: Cold carcass weight

## 4.2 Meat Colour and pH

Results of meat colour of breast, thigh and drumstick of indigenous chickens are presented in Table 4.2. Lightness, redness and yellowness of thigh and drumstick, including lightness of breast meat were breed, sex and time dependent. However, redness and yellowness of the breast meat were not influenced by breed, sex or time.

The effects of breed, sex and time on meat pH of indigenous chickens are shown on Table 4.3, Figures 4.1, 4.2 and 4.3, respectively. The breast meat of the PK breed had higher ($p$ <0.05) pH values than those of the Ovambo chickens. Time of meat storage had an effect ($p$ <0.05) on breast meat pH. A post mortem period of 24 hours resulted in the breast meat having higher ($p$ <0.05) pH values than 0.5 and 48 hour period. However, a post mortem ageing of 0.5 hours resulted in lower ($p$ <0.05) pH values than 48 hours post-mortem. For the thigh meat, male chickens had higher ($p$ <0.05) pH values than females. Age did not affect ($p$ >0.05) thigh pH values of Ovambo breed while in PK chicken, meat aged for 0.5 hours yielded meat with lower ($p$ <0.05) pH values than meat aged for 48 hours. Drumstick meat from Ovambo chickens had higher ($p$ <0.05) pH values than meat from PK chickens.

**Table 4.2**. Meat colour (CIE values) of different meat parts of male and female indigenous chickens

| Variable | | Breast | | | Thigh | | | Drumstick | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L* | a* | b* | L* | a* | b* | L* | a* | b* |
| Genotye | | | | | | | | | | |
| | PK | 51.21 | 5.72 | $14.11^{b}$ | 41.67 | 13.38 | $9.22^{b}$ | $44.62^{a}$ | $11.90^{b}$ | $11.27^{b}$ |
| | Ovambo | 48.23 | 9.56 | $19.15^{a}$ | 42.31 | 13.68 | $14.06^{a}$ | $39.02^{b}$ | $14.09^{a}$ | $12.15^{a}$ |
| | SE | 1.441 | 1.421 | 1.439 | 0.1611 | 0.1288 | 0.307 | 0.0518 | 0.0307 | 0.0301 |
| Sex | | | | | | | | | | |
| | Female | $52.91^{a}$ | $4.29^{b}$ | 16.20 | $45.94^{a}$ | $11.15^{b}$ | $13.56^{a}$ | $45.27^{a}$ | $11.13^{b}$ | $12.98^{a}$ |
| | Male | $46.54^{b}$ | $10.98^{a}$ | 17.05 | $37.55^{b}$ | $15.91^{a}$ | $9.72^{b}$ | $38.37^{b}$ | $14.86^{a}$ | $10.45^{b}$ |
| | SE | 1.441 | 1.421 | 1.439 | 0.161 | 0.1288 | 0.3072 | 0.052 | 0.031 | 0.031 |
| Time (hours) | | | | | | | | | | |
| | 0.5 | 50.32 | $6.06^{b}$ | $13.11^{b}$ | $46.14^{a}$ | $10.00^{b}$ | $10.03^{b}$ | $46.55^{a}$ | $10.60^{b}$ | $11.19^{b}$ |
| | 24 | 46.51 | $11.81^{a}$ | $19.06^{a}$ | $39.43^{b}$ | $15.27^{a}$ | $11.01^{b}$ | $40.01^{b}$ | $14.18^{a}$ | $11.16^{b}$ |
| | 48 | 52.34 | $5.04^{b}$ | $17.72^{ab}$ | $39.66^{b}$ | $15.21^{a}$ | $13.88^{a}$ | $38.91^{c}$ | $14.21^{a}$ | $12.78^{a}$ |
| | SE | 1.765 | 1.741 | 1.762 | 0.197 | 0.158 | 0.376 | 0.063 | 0.038 | 0.037 |
| | | Probabilities | | | | | | | | |
| Effects | | | | | | | | | | |
| | Breed | 0.1570 | 0.0685 | 0.0208 | <0.0001 | 0.1121 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| | Sex | 0.0046 | 0.0028 | 0.6800 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| | Breed*Sex | 0.0364 | 0.074 | 0.0982 | <0.0001 | <0.0001 | 0.4808 | <0.0001 | <0.0001 | <0.0001 |
| | Time | 0.0796 | 0.0235 | 0.0613 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| | Breed*Time | 0.0138 | 0.492 | 0.4581 | <0.0001 | <0.0001 | 0.062 | <0.0001 | <0.0001 | <0.0001 |
| | Sex*Time | 0.0104 | 0.1169 | 0.1391 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| | Breed*Sex*Time | 0.0361 | 0.1335 | 0.3455 | <0.0001 | <0.0001 | 0.0004 | <0.0001 | <0.0001 | <0.0001 |

[a,b] Means within rows with different superscripts differ significantly ($p$ <0.05)
SE: Standard error.
PK: Potchefstroom koekoek

**Table 4.3** Effects of genotype, sex and time period after slaughter on meat pH

| Variable | | Breast | Thigh | Drumstick |
|---|---|---|---|---|
| Genotype | | | | |
| | PK | 5.54[a] | 5.71 | 5.77[b] |
| | Ovambo | 5.45[b] | 5.71 | 5.86[a] |
| | SE | 0.015 | 0.015 | 0.025 |
| Sex | | | | |
| | Female | 5.48 | 5.67[b] | 5.79 |
| | Male | 5.51 | 5.76[a] | 5.84 |
| | SE | 0.048 | 0.015 | 0.025 |
| Time (hours) | | | | |
| | 0.5 | 5.44[c] | 5.67[b] | 5.77 |
| | 24 | 5.55[a] | 5.74[a] | 5.84 |
| | 48 | 5.50[b] | 5.74[a] | 5.84 |
| | SE | 0.018 | 0.019 | 0.030 |
| | | Probabilities | | |
| Effects | | | | |
| | Breed | <0.0001 | 0.5949 | 0.0102 |
| | Sex | 0.0802 | 0.0002 | 0.2103 |
| | Breed*Sex | 0.849 | 0.9394 | 0.9542 |
| | Time | <0.0001 | 0.0197 | 0.1462 |
| | Breed*Time | 0.0612 | 0.00231 | 0.3767 |
| | Sex*Time | 0.3507 | 0.4549 | 0.4377 |
| | Breed*Sex*Time | 0.2143 | 0.8453 | 0.8052 |

[a,b,c] :Means in a column not sharing a common superscript are significantly different ($p$ <0.05)
SE: Standard error
PK: Potchefstroom koekoek

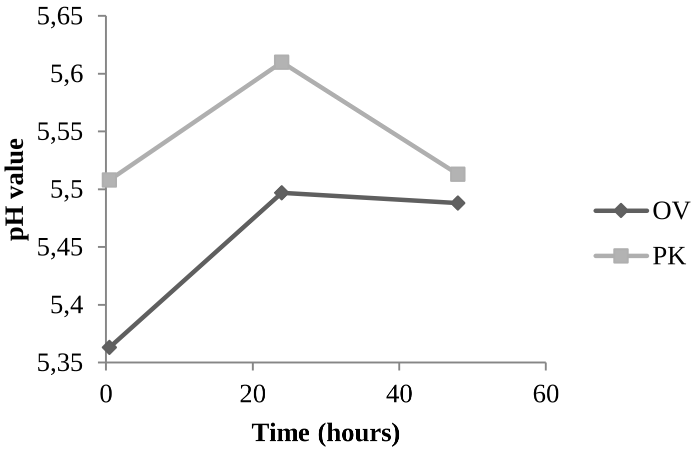


Figure 4.1 Breast meat pH value

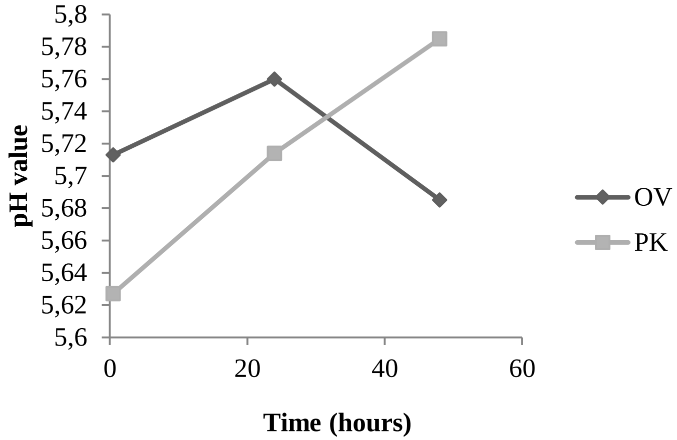


Figure 4.2 Thigh meat pH values

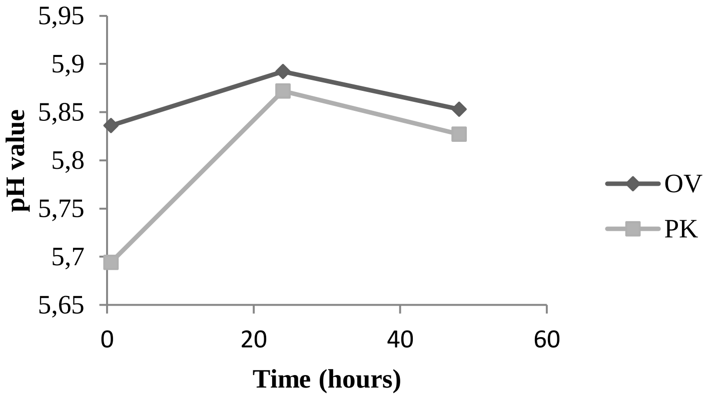


Figure 4.3 Drumstick meat pH value

### 4.3 Fatty Acid Profile

The fatty acid composition of male and female Ovambo and PK breast chicken meat is shown in Table 4.4. Interactions between breed and sex effects were not ($p$ >0.05) significant. Muscles of the Ovambo breed had higher ($p$ <0.05) eicosatrienoic and saturated fatty acid (SFA) contents than the PK breed. Females had higher ($p$ <0.05) myristic (C14:0), palmitoeic (C16:1c9), palmitic (C16:0), heptadecenoic (C17:1c10) and oleic acid (C18:1c9) content in their muscles than male indigenous chickens. However, male chicken muscles had higher ($p$ <0.05) stearic (C18:0), γ-linolenic (C18:3c6,9,12 (n-3)), arachidic (C20:0), eicosedienoic (C20:2c11,14 (n-6)), arachidonic (C20:4c5,8,11,14 (n-6)), eicosopentaenoic (C20:5c5,8,11,14,17 (n-3)), docosapentaenoic acid (C22:5c7,10,13,16,19 (n-3)) than muscles of female indigenous chickens. Female muscles had higher ($p$ <0.05) monounsaturated fatty acid and polyunsaturated fatty acid contents than muscles of male indigenous chickens. Male chicken muscles had higher ($p$ <0.05) omega-6, omega-3 and polyunsaturated fatty acid: saturated fatty acid ratio than female indigenous chickens.

**Table 4.4** The fatty acid composition (%) of breast meat of male and female indigenous chickens

| | Genotype | | | | Sex | | | |
|---|---|---|---|---|---|---|---|---|
| | Ovambo | PK | SE | P-value | Female | Male | SE | p-value |
| FAT | 1.022 | 1.255 | 0.1006 | 0.0639 | 1.284 | 0.993 | 0.1006 | 0.1291 |
| FatFreeDM | 24.370 | 24.236 | 0.3787 | 0.8070 | 24.210 | 24.396 | 0.3787 | 0.7353 |
| Moisture | 74.608 | 74.509 | 0.4927 | 0.8780 | 74.506 | 74.611 | 0.4426 | 0.8696 |
| SFA | | | | | | | | |
| C14:0 | 0.256 | 0.304 | 0.0305 | 0.2710 | $0.349^{a}$ | $0.211^{b}$ | 0.0305 | 0.0059 |
| C15:0 | 0.029 | 0.037 | 0.0086 | 0.5319 | 0.035 | 0.030 | 0.0086 | 0.6837 |
| C16:0 | 23.651 | 23.279 | 0.4325 | 0.5745 | $24.624^{a}$ | $22.306^{b}$ | 0.4325 | 0.0041 |
| C17:0 | 0.787 | 0.582 | 0.0877 | 0.1243 | $0.574^{a}$ | $0.796^{b}$ | 0.0877 | 0.0992 |
| C18:0 | 12.848 | 11.607 | 0.5094 | 0.1112 | $10.981^{b}$ | $13.473^{a}$ | 0.5094 | 0.0048 |
| C20:0 | 15.262 | 13.231 | 1.6081 | 0.3904 | $11.739^{b}$ | $16.754^{a}$ | 1.6081 | 0.0481 |
| C22:0 | 0.064 | 0.030 | 0.0118 | 0.0650 | 0.036 | 0.058 | 0.0118 | 0.2093 |
| MUFA | | | | | | | | |
| C16:1 | 1.365 | 1.939 | 0.2216 | 0.0926 | $2.105^{a}$ | $1.199^{b}$ | 0.2216 | 0.0137 |
| C18:1n9c | 23.021 | 25.805 | 1.4840 | 0.2102 | $27.515^{a}$ | $21.312^{b}$ | 1.4840 | 0.0121 |
| C18:1n11 | 3.847 | 4.197 | 0.1825 | 0.2012 | 4.144 | 3.900 | 0.1825 | 0.3639 |
| C20:1n9 | 0.167 | 0.157 | 0.0216 | 0.7672 | 0.162 | 0.162 | 0.0216 | 0.9811 |
| PUFA | | | | | | | | |
| C18:2 | 14.799 | 15.386 | 0.7722 | 0.6016 | 14.779 | 15.406 | 0.7722 | 0.5771 |
| C18:3n3 | 0.135 | 0.195 | 0.0294 | 0.1794 | 0.195 | 0.135 | 0.0294 | 0.1726 |
| C18:3n6 | 0.033 | 0.053 | 0.0127 | 0.2846 | $0.065^{b}$ | $0.021^{a}$ | 0.0127 | 0.0287 |
| C20:2n6 | 0.267 | 0.197 | 0.0323 | 0.1535 | $0.149^{b}$ | $0.315^{a}$ | 0.0323 | 0.0035 |
| C20:4 | 0.083 | 0.099 | 0.0151 | 0.4924 | $0.044^{b}$ | $0.137^{a}$ | 0.0151 | 0.0010 |
| C20:5n3 | 0.018 | 0.034 | 0.0109 | 0.3239 | $0.009^{b}$ | $0.044^{a}$ | 0.0109 | 0.0429 |
| C22:5n3 | 0.994 | 0.817 | 0.1456 | 0.4074 | $0.593^{b}$ | $1.218^{a}$ | 0.1456 | 0.0104 |
| C22:6n3 | 1.645 | 1.434 | 0.1963 | 0.4612 | 1.310 | 1.768 | 0.1963 | 0.1254 |
| TOTAL | | | | | | | | |
| SFA | $36.902^{a}$ | $35.469^{b}$ | 0.3542 | 0.0145 | 36.048 | 36.323 | 0.3542 | 0.5936 |
| MUFA | 29.188 | 32.680 | 1.7764 | 0.1905 | $34.500^{a}$ | $27.368^{b}$ | 1.7764 | 0.0151 |
| PUFA | 33.912 | 31.850 | 1.6357 | 0.3911 | $29.453^{a}$ | $36.309^{b}$ | 1.6357 | 0.0120 |
| Omega-6 | 31.086 | 29.317 | 1.3640 | 0.3781 | $27.280^{b}$ | $33.123^{a}$ | 1.3640 | 0.0106 |
| Omega-3 | 2.826 | 2.533 | 0.3039 | 0.5086 | $2.173^{b}$ | $3.186^{a}$ | 0.3039 | 0.0365 |
| PUF:SFA | 0.920 | 0.896 | 0.0449 | 0.8047 | $0.814^{b}$ | $1.002^{a}$ | 0.0449 | 0.0080 |
| n-6 :n-3 | 10.967 | 12.928 | 1.0320 | 0.2046 | 13.210 | 10.685 | 1.0320 | 0.1099 |

$^{a,b}$ Means within rows with different superscripts differ significantly ($p$ <0.05)
SE: Standard error
SFA: Saturated fatty acid. MUFA: Monounsaturated fatty acid. PUFA: Polyunsaturated fatty acid

Meat sensory evaluation of Ovambo and PK chickens are shown in Table 4.5. There were no breed differences ($p$ >0.05) observed in taste, flavour, juiciness, aroma and overall acceptance between Ovambo and PK chickens meat. Although meat from female indigenous chickens scored better in the meat sensory evaluation, no significant ($p$ >0.05) differences were observed between male and female meat. Meat from PK chickens had higher ($p$ <0.05) shear force values than meat of Ovambo chickens.

**Table 4.5** Sensory evaluation and shear force analysis (Warner Bratzler, N) of male and female indigenous chicken breast meat

| | Genotype | | | | Sex | | | |
|---|---|---|---|---|---|---|---|---|
| | Ovambo | PK | SE | p-value | Female | Male | SE | p-value |
| Taste | 3.08 | 3.18 | 0.171 | 0.6811 | 3.15 | 3.10 | 0.171 | 0.8371 |
| Flavour | 2.95 | 3.08 | 0.168 | 0.5995 | 3.05 | 2.98 | 0.168 | 0.7526 |
| Juiciness | 3.03 | 2.98 | 0.190 | 0.8531 | 3.08 | 2.93 | 0.190 | 0.5788 |
| Tenderness | 2.75 | 2.98 | 0.170 | 0.3535 | 2.98 | 2.75 | 0.170 | 0.3535 |
| Aroma | 2.83 | 2.90 | 0.182 | 0.2883 | 3.00 | 2.73 | 0.182 | 0.7714 |
| Overall acceptance | 3.13 | 3.43 | 0.180 | 0.2420 | 3.20 | 3.35 | 0.180 | 0.5572 |
| Shear force | $42.11^{b}$ | $51.96^{a}$ | 0.537 | 0.0194 | 47.98 | 46.09 | 0.537 | 0.6303 |

$^{a,b}$ Means within rows with different superscripts differ significantly ($p$ <0.05)
SE: Standard error    PK: Potchefstroom koekoek

# CHAPTER 5

# DISCUSSION AND CONCLUSIONS

## 5.1 Carcass Yield

At 18 weeks of age genotype did not affect carcass characteristics of the selected indigenous chickens, which is consistent with Packard (2014) who indicated that similar carcass traits were observed amongst indigenous chickens. However, Isidahomen *et al.* (2012) showed significant differences in the carcass characteristics of Nigerian indigenous chicken genotypes used in their study. According to Young *et al.* (2001), Havenstein *et al.* (2003) and Brickett *et al.* (2007), carcass yield is affected by genetic, feed, slaughtering conditions, body weight and sex. In addition, low body weight is associated with low carcass yield (De Marchi *et al*., 2005; Fanatico *et al.*, 2005b; Moujahed and Haddad, 2013). The birds used in this study had similar body weight gain, hence, the low carcass yield and parts could be attributed to low live weight of chickens.

Sex affected the body weight, hot and chilled carcasses of indigenous chickens. Male chickens had predominantly heavier body weight, hot and chilled carcass weights than their counterparts. These findings were similar to those Joseph *et al.* (1992) and Isidahomen *et al.* (2012) who observed that male indigenous chickens had a remarkably and better carcass traits than female chickens. Male chickens irrespective of strain had superior live and carcass weights compared to their females (Gous *et al.,* 1999; Scheuermann *et al.,* 2003; Abudulla *et al*., 2010). The differences observed between male and female chickens may be as a result of sexual dimorphisms which tend to favour males over females in poultry (Garcia *et al.,* 1991; Ilori *et al.,* 2010). Some reports suggest that the sex differences might be due to physiological activities and aggressiveness especially if both sexes are reared together (Ilori *et al.,* 2010; Isidahomen *et al*., 2012). The aggressiveness of males over the females put the females at a disadvantage for feed and water.

## 5.2 Colour and pH Values

Physical characteristics of muscle such as colour are one of the first traits noticed by consumers and thus an indicator of meat quality (Owens *et al*., 2000; Woelfel *et al.,* 2002). Colour is immediately discerned by consumers when purchasing meat products (Fanatico *et al.*, 2007b). The L* value indicates the paleness of meat, with a high L* associated with poor meat quality (Holownia *et al*., 2003; Wattanachant *et al.,* 2004). In the present study, genotype, sex and time interactions were observed in the thigh and drumstick meat. The Ovambo chicken breast, thigh and drumstick meat were more yellow than the PK chicken. These results are supported by Packard (2014) which indicated that lower b* values were recorded for PK chickens. Kücükyilmaz *et al*. (2012) observed that thigh and breast meat of slow-growing birds kept indoors and grown under the organic production system were brighter and yellower when compared with fast-growing birds. Meat and skin colour depends on the melanin pigment production ability of the dermis and epidermis and also on absorption and storage of carotenoid pigments in the epidermis (Fletcher, 1999a). Other factors that influence skin colour are genetics and feeding (Xiong et al., 1999), and the present study confirmed the presence of a strong genetic influence. Furthermore, Gordon and Charles (2002) found that slow-growing birds have a more red meat colour than fast-growing birds because slow-growing birds are typically older, while Fanatico *et al*. (2007) observed that the slow-growing birds were less red (lower a*) than the fast-growing birds. Ovambo and PK female chickens had lighter meat (*L) than their male counterparts. Myoglobin is the primary protein affecting meat colour, with haemoglobin and cytochrome C also playing a role (Mancini and Hunt, 2005; Fanatico *et al.,* 2007b). Myoglobin is present in higher amounts in muscles with a higher workload. As a result, leg muscles tend to have a higher content of myoglobin and as a result a darker colour (Fanatico *et al*., 2007a; Tlhong, 2008). The tendency of male chickens to have darker meat as observed in this study could be associated with higher physical activities (Wattanachant, 2004, Packard, 2014).

Meat pH of different meat parts was different between the chicken breeds. Higher pH values were recorded for the PK chicken breast meat whilst the drumstick of Ovambo chickens had higher pH. According to Castellini *et al*. (2002) and Muchenje *et al.* (2009a), a pH fall pattern is usually observed in poultry muscles over a post-mortem aging period. The pH fall is due to the fact that the slaughtered chickens' glycogen is broken down into glucose, which undergoes glycolysis but in the absence of oxygen, lactic acid is formed which causes pH muscles to drop (Muchenje *et al*., 2009a). The lower pH of chicken could also be due to the better welfare conditions that reduce the stress pre-slaughter and thus consumption of glycogen (Castellini *et al.,* 2002). According to Owens et al. (2000) and Woelfel *et al.* (2002), muscle pH decreases after slaughter, and a low pH can inhibit Water Holding Capacity (WHC) and other muscular functions. However, higher pH also negatively affects meat quality, because it creates a more favourable environment for bacterial growth (Fanatico *et al*., 2007a). In the current study, the range of $pH_{24h}$ values were from 5.554 to 5.837 in the two chicken lines, and falls within the normal range as described by Xiao (2007). In the current study, pH of the breast and drumstick of both chicken breed increased, reaching a peak and then decreased. Contrary to the other muscles evaluated in the current study, the pH of the thigh meat of the PK chicken increased with an increase in aging period.

### 5.3 Fatty Acids Composition

Of importance with regards to human health are the proportion of TUFA, n-3 and n-6 fatty acids, and the ratio of n-6/n-3 fatty acids in food. Western diets are deficient in n-3 fatty acids, and have an excessive amount of n-6 fatty acids which is believed to promote the pathogenesis of many cardiovascular and autoimmune diseases (Simopoulos, 2002). Fatty acids were higher than those observed by Wattanachant *et al.* (2004). These authors indicated that there are some fatty acids present in the muscles of indigenous chickens but not broiler chickens. Van Marle-Koster and Webb (2000) and Polak *et al.* (2002) noted that fatty acid composition in chicken meat are affected by many factors such as species, rearing system, genotype, anatomical part, diet and dietary fat. Van Marle-Koster and Webb (2000) indicate that indigenous chickens tend to scratch while eating and have been observed to pick up feed particles more selectively than broilers which may affect their fatty acid composition. Since the chickens in the present study received a similar diet, differences in the proportions of these fatty acids seems to be largely attributable to sex differences. Female chickens had higher mono and polyunsaturated fatty acids compared to males. However, omega 6 and 3 fatty acids were higher for male than female chickens. The n-3 fatty acids have potential to prevent and treat cardiovascular disease, some autoimmune disorders, diabetes, and some types of cancer (Gonzalez-Esquerra and Leeson, 2000). In addition, the ratio of n-6 to n-3 fatty acids is an important determinant of health. A lower ratio of n-6 to n-3 fatty acids is more desirable in reducing the risk of many diseases (Simopoulos, 2002). The ratio observed in this study was lower than that reported for broiler chicken meat (Molee *et al*., 2012).

Taste, flavour, juiciness, tenderness, aroma and overall acceptability of the Ovambo and PK chickens used in the current study were similar. When indigenous chickens were compared with conventional chickens (Dyubele *et al*., 2010), the broiler chicken meat received higher consumer sensory scores. The similarity in consumer sensory scores between the two indigenous breeds used in the current study can be explained by the similarities in the fatty acid profiles. Shear force is used to assess meat tenderness, and higher shear force means tougher meat quality (Cavitt et al., 2004). The shear force values of the PK chicken breast meat were higher than those reported for Ovambo chickens. This can be explained by the differences in the muscle fibre size. Longer fibre diameters are often associated with higher shear force and meat toughening (Guan *et al*., 2013). However, this observation was not supported by the tenderness consumer sensory scores obtained in the current study.

### 5.4 Conclusions

Similar carcass traits were observed between the PK and Ovambo chickens. The pH and meat colour of the different meat parts at different periods did not vary significantly between the chicken breeds. The omega 6 and 3 fatty acids and their ratios were reported to be in the ranges required for promoting health for consumers. The fatty acid profiles influenced the sensory attributes of the indigenous chicken meat. This information can help consumers make a knowledgeable choice regarding teat preferences which may positively impact their health.

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