Comparison of Production Parameters and Meat Quality Characteristics of South African Indigenous Chickens

By

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Declaration

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Abstract

This study quantified the growth performance, carcass and meat characteristics of South African slow-growing chicken lines. Two slow-growing lines developed outside South Africa, the Black Australorp and New-Hampshire, two native lines including the Naked-Neck and Potchefstroom Koekoek, as well as a hybrid between a Cobb 500 broiler and Potchefstroom Koekoek were evaluated. Fifty birds of each line were randomly allocated to cages of five birds per cage where they were fed a standard broiler diet *ad libitum* to an average weight of 2kg. Twenty cockerels of each line were then slaughtered for further analyses. For the carcass characteristics: live weight at slaughter, hot carcass weight, and chilled carcass weight were determined. Portion yields and dissection characteristics were measured, and the deboned meat from the breast, thigh and drumstick analysed for proximate analysis and fatty acids.

Average daily gain (ADG), feed conversion ratio (FCR), and European Production Efficiency Factor (EPEF) were calculated and analyzed for line differences. No significant differences were observed between the indigenous lines with regards to feed intake ADG (~22g), FCR (~3.65), and EPEF (~57). The Hybrid outperformed the indigenous lines for all of the growth performance parameters measured.

No differences were observed for dressing %. The breast yield obtained by the Hybrid was significantly higher (45.56%) than that of the indigenous lines which had similar breast yield values (~41%). The naked-Neck had the highest thigh yield and the lowest drumstick percentage yield, 27.7% and 17.3%, respectively. A similar pattern was observed for drumstick yield with the Australorp, New-Hampshire and Koekoek lines having significantly higher yields than those of the Hybrid. For the tissue characteristics, similar values were seen for breast skin (~20%), breast bone (~22%), drumstick skin (~4.3%), and drumstick muscle (~27%). The Hybrid had significantly higher breast muscle, thigh muscle, and total muscle percentage yield (22.67%, 26.17% and 43.51%, respectively).

Proximate chemical composition of the breast samples did not differ ($P>0.05$) for any parameters. Differences ($P<0.05$) were recorded for thigh moisture, protein and ash content. The Naked-Neck recorded the lowest moisture (72.3%) and the highest protein (18.6%) and ash (1.1%) values. Differences were also recorded for drumstick moisture protein and fat. The highest moisture content was measured for the Hybrid (75.9%) and the lowest for the Naked-Neck (73.6%). The indigenous lines had higher protein content (~19.5%) when compared to the Hybrid (18.9%). The drumstick fat content for the Naked-necks (4.4%) was higher than the remaining lines.

Differences were observed for the fatty acid profile. Total PUFA differed (P<0.05) with the Australorp (28.2%) showing the highest proportion. The relative contributions of total SFA, total MUFA and TUFA did not differ significantly between lines. The ratio of polyunsaturated and saturated fatty acids, the proportion of n-6 fatty acids and the ratio of n-6/n-3 differed, higher values were recorded for the indigenous lines. The proportion of n-3 fatty acids did not differ.

The Hybrid performed significantly better than the indigenous lines but did not reach the performance potential expected for commercial broilers. Despite this, the Hybrid does show potential for use in alternative practices that make use of slower growing lines.

Opsomming

Hierdie studie het die groei-prestasie, karkas- en vleiskwaliteitseienskappe van Suid Afrikaanse inheemse hoenders gekwantifiseer. Vier plaaslike lyne, die Swart Ostralorp, New Hampshire, Kaalnek en Potchefstroomse Koekoek, sowel as ’n kruising van die Koekoek henne met Cobb 500 braaikuikenhane is evalueer. Vyftig voëls van elke genotipe is ewekansig ingedeel in hokke met vyf voëls per hok. ’n Standaard braaikuiken dieet is gevoer totdat die gemiddelde massa van die kuikens 2kg bereik het. Daarna is 20 hane van elke genotipe geslag vir verdere analise. Vir karkaseienskappe is lewendige massa voor slag, warm karkasmassa en koue karkasmassa bepaal. Daarna is porsie opbrengs en disseksie eienskappe bepaal en, en die ontbeende vleis van die bors, dy en been is ontleed vir proksimale en vetsuur analises.

Gemiddelde daaglikse toename (GDT), voeromsetverhouding (VOV), en Europese produksie effektiwiteits faktor (EPEF) is vir die verskillende genotipes bereken en getoets vir verskille. Geen betekenisvolle verskille is waargeneem vir inname, GDT (~22g), VOV (~3.65), en EPEF (~57) nie. Die kruisras het in alle gevalle beter produksieparameters gelewer as die plaaslike lyne.

Geen verskille is opgemerk vir uitslagpersentasie nie. Die borsopbrengs van die kruisras was betekenisvol hoër (45.66%) as die van die plaaslike lyne (~41%). Die Kaalnek het die hoogste dyopbrengs (27.7%) en die laagste beenopbrengs (17.3%) gelewer. ’n Soortgelyke patroon is waargeneem vir die beenopbrengs van Australorp, New-Hampshire en Koekoek met betekenisvol hoër opbrengste as dié van die kruisras. Weefsel eienskappe het dieselfde opbrengs gelewe vir die plaaslike lyne met borsvel (~20%), borsbeen (~22%), beenvel (~4.3%) en beenspier (~27%). Die kruisras het betekenisvol meer borsvleis, dyspier en totale spierpersentasie gelewer as al die ander genotipes (onderskeidelik 22.67%, 26.17% en 43.51%).

Proksimale analise van die borsmonsters het geen verskille (P>0.05) gelewer vir enige van die parameters wat bepaal is nie. Verskille is opgemerk vir die vog-, proteïen- en as-inhoud van die dyspier. Die Kaalnek het die laagste voginhoud (72,3%) en die hoogste proteïen- (18.6%) en as-inhoud (1.1%) gehad. Verskille is ook opgemerk vir been vog-, proteïen- en vetinhoud. Die hoogste voginhoud is gemeet in die kruisras (75.9%) en die laagste in die Kaalnek (73.6%). Die plaaslike lyne het 'n hoër proteïeninhoud (~19.5%) as die kruisras (18.9%) gehad. Die vetinhoud van die beenspier was ook die hoogste vir die Kaalnek (4.4%).

Verskille is waargeneem vir die vetsuurprofiele van vleis. Die PUFA het verskil, met die hoogste persentasie waargeneem vir die Australorp (28.2%). Die verhoudelike bydrae van die totale SFA, totale MUFA en TUFA het nie betekenisvol tussen genotipes verskil nie. Die verhouding van n-3 vetsure het ook nie verskil nie. Die verhouding van die PUFA:SFA, die verhouding van n-6 vetsure en die verhouding van n-6/n-3 vetsure het verskil, met hoër waardes vir die plaaslike lyne. Die verhouding van n-3 vetsure het nie verskil nie.

Die kruisras het oor die algemeen betekenisvol beter gevaar as die plaaslike lyne, maar het steeds nie die produksie potensiaal van die kommersiële braaikuiken bereik nie.

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List of Abbreviations

a*	Red-green Range
ADG	Average Daily Gain
b*	Blue-yellow Range
CCW	Chilled Carcass Weight
DFD	Dark, Firm and Dry
EPEF	European Production Efficiency Factor
FCR	Feed Conversion Ratio
g	Grams
GDP	Gross Domestic Product
kg	Kilograms
L*	Lightness
LWS	Live Weight at Slaughter
MUFA	Monounsaturated Fatty Acids
pH_i	Initial pH
pH_u	Ultimate pH
PSE	Pale Soft and Exudative
PUFA	Polyunsaturated Fatty Acids
SFA	Saturated Fatty Acids
TUFA	Total Unsaturated Fatty Acids

Notes

This thesis represents a compilation of manuscripts; each chapter is an individual entity and some repetition between chapters, especially in the Materials and Methods sections, is therefore unavoidable.

Contents

Chapter 1

General Introduction

1.1 Introduction

Indigenous chickens are considered an important genetic resource with renewed efforts being made to save these unique lines. It has been shown that they have a very important socioeconomic role to play in poor rural communities. Backyard indigenous chickens provide rural communities with a means to convert available feed-stuffs around the household or village into highly nutritious products, i.e. meat and eggs (Mtileni *et al*., 2011). Malnutrition is a common phenomenon, especially in the developing world, resulting in an increased demand for good quality protein. This has resulted in an increase in the production of poultry and pigs for human consumption, of which poultry makes the largest contribution to the animal-source of foods (Mengesha, 2012).

The South African poultry meat industry is considered the country's largest individual agricultural industry, worth a gross value of more than R27 billion per annum (Kreamer, 2013). The per capita consumption of poultry meat by South African consumers was estimated at 36kg per annum, roughly double that of beef and five times that of pork (Kreamer, 2013). Over the past decade the estimated number of chickens in the South African poultry industry increased by 50% to 156.255 million chickens, 80% of which were used for meat consumption (Anonymous, 2012). Commercial broilers have been bred to suit the demands of the poultry meat market. Most of the changes seen in broiler growth and carcass characteristics (85-90%) have been a result of quantitative selective breeding practiced by commercial breeding organisations (Havenstein *et al*., 2003).

The broiler industry has had to adjust its strategies to accommodate the increased demand. It has done this through technological advances in animal production and processing (value-added products) (Hoffmann, 2005). Selective breeding in conjunction with improved genetics, well-organized production systems, highly specialised nutrition and regular veterinary attention has produced a large, fast growing bird with high breast muscle yield that can reach market weight in as little as 5 weeks (Fanatico *et al*., 2007). Although, the gains achieved in growth rate and muscle mass have resulted in the appearance of sensory and functional quality defects in commercial broiler meat. This, in conjunction with a growing awareness of human health and nutritional concerns, has led to the development of specialty markets aimed at poultry produced in alternative production systems such as free-range or organic (Fanatico *et al*., 2007). Free-range and organic production systems make use of slower-growing lines that are provided with improved conditions and standards in rearing. A slower growth rate and free-range for greater activity are believed to be important factors contributing to the production of better quality meat and carcasses in chickens (Cheng *et al*., 2008), factors sought after by 'modern' consumers.

The development of indigenous poultry as a commercial enterprise is highly dependent on whether or not consumers find that the product meets their demands in terms of meat quality (chemical and sensory) and animal welfare, factors dependent growth rate and genetics. Thus the need to identify breeds that suit these demands and quantify their suitability with regards to production performance is essential. In Taiwan nearly half of all poultry products consumed come from indigenous chickens, whereas in the west almost all poultry meat consumed comes from commercial broilers (Cheng *et al*., 2008). The success of the French *Label Rouge* program in Europe, despite a higher retail price, is evidence of the shift in preference towards 'greener' poultry production (Fanatico *et al*., 2005). Birds raised in the systems employed by the French *Label Rouge* program have been shown to have 10% more muscle development resulting in a firmer textured, darker coloured meat with more desirable flavour and less inter- and intramuscular fat (Bogosavljevic-Boskovic *et al*., 2010).

Although the production potential of indigenous chicken lines is low in comparison to commercial broilers, they have the added advantages of having evolved the ability to adapt and survive under a range of challenging environmental and ecological conditions. They are hardy and require low levels of input for production (Van Marle-Köster *et al*., 2009; Dyubele *et al*., 2010). More recently focus has shifted to the quality aspects of meat as opposed to the quantity of meat produced, which has been the norm, thereby providing an opportunity for market segmentation (Fanatico *et al*., 2007). In order to promote the use of indigenous lines for commercial production, information on their meat quality and carcass characteristics is essential.

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Chapter 2

Literature review

2.1 Introduction

Over the years, since the introduction of poultry to South Africa, the keeping of chickens has developed from what was primarily a backyard industry to what is today a highly specialised, efficient commercial enterprise (Anonymous, 2012). The commercial broiler industry has expanded enormously over the past several decades, growing roughly 4% per year for the past ten years (Havenstein *et al*., 2003; Jez *et al*., 2011). With a gross value of roughly R27 billion, the South African broiler industry is considered to be the largest individual agriculture industry contributing to almost 17% of the total gross value of agricultural products (Kreamer, 2013).

An ever growing population, income growth and urbanisation have driven up the demand for meat and other livestock products in developing countries. Recent decades have seen the consumption of poultry meat in developing countries increase by more than double the increase seen in developed countries (Sandilands & Hocking, 2012). The global consumption of chicken meat also increased dramatically, by more than 32 million tons since 2000 to roughly 91 million tons in 2012 (Anonymous, 2012a).

Commercial broilers have been bred to suit the demands of the poultry meat market. Most of the change seen in broiler growth and carcass characteristics (85-90%) has been a result of quantitative selective breeding practiced by commercial breeding organisations (Havenstein *et al*., 2003). Selective breeding in conjunction with improved genetics, well-organized production systems, highly specialised nutrition and regular veterinary attention has produced a large, fast growing bird with high breast muscle yield that can reach market weight in as little as 5 weeks (Fanatico *et al*., 2007).

Over the past 30 years, selection has focused on muscle mass and growth velocity, halving the time taken for a broiler to reach market weight (Dransfield & Sosnicki, 1999). Selecting for fast growth and high yield has likely had an undesirable impact on the sensory and functional qualities of poultry meat (Fanatico *et al*., 2007). Sensory traits as well as the chemical composition of the meat are taken into account when assessing meat quality. Special attention is paid to the percentage and composition of the fat occurring in poultry products when consumers regard the health aspects of meat products (Holcman *et al*., 2003). More recently, focus on the quality aspects of meat as opposed to the quantity of meat produced has provided an opportunity for market segmentation (Fanatico *et al*., 2007).

South African domestic chickens have more recently been considered an important genetic resource (Mtileni *et al*., 2011). This increased interest in domestic poultry lines is associated with a growing awareness of human health and nutritional concerns, and animal (bird) welfare which has led to the development of specialty markets for chickens produced in alternative systems (Fanatico *et al*., 2007). Information on the meat quality and carcass characteristics of domestic lines is essential to promoting their production, even on a large scale (Dyubele *et al*., 2010).

2.2 South African Poultry Industry

The growth seen in the local poultry industry is a direct result of an increased demand for poultry products, which are considered superior with regards to health aspects when compared to red meat. Poultry meat is reasonably priced in comparison to red meat and is available portioned and packaged for convenience and lacks religious restrictions on its consumption (Dyubele *et al*., 2010). In the majority of developing countries in Africa and Asia, the development of the commercial poultry industry began in the past three decades (Nthimo, 2004). The poultry industry is now the largest agricultural sector in South Africa (contributing an approximate 24% of agricultural income) with more poultry products being consumed than all other animal protein sources combined (Anonymous, 2012a; Anonymous, 2012b). In 2012 alone South Africa consumed roughly 1.8 million tons of broiler meat, which equates to a rise of 70% since 2000 (Esterhuizen, 2013).

The South African poultry industry can be divided into two main sub-sectors: a large-scale commercial sub-sector and a small-scale subsector. The commercial sub-sector overshadows the small-scale sector by making use of advanced housing systems and intensive feeding and management programs (Van Marle-Köster, 2001). In addition to this, modern broiler breeding practices have been focused towards high output in one or a few major traits that suit the market, for example breast meat production (Hoffmann, 2005). The genetics employed by broiler breeders has significantly increased growth rate, whilst indirectly reducing feed conversion, thus lowering the age at which a broiler reaches market weight (Emmerson, 1997).

Since the development of the commercial poultry industry, genetic selection has largely been focused on enhanced production (Hoffmann, 2005). Although there has been a global understanding of the need to increase poultry production and yield, the use of and improvement of domestic/native poultry has largely been ignored and not included in mainstream agriculture (Rodriguez & Preston, 1997). Although their total output is low in comparison to commercial lines, domestic poultry production systems can be productive thanks to the low input levels required (Nthimo, 2004).

2.3 Domestic Poultry in South Africa

The importance of domestic lines to rural food security and culture is well documented (Swatson *et al*., 2002; Van Marle-Köster *et al*., 2009; Mtileni *et al*., 2011). Resource-poor farmers throughout Africa and Asia keep chickens to satisfy their protein requirements. Indigenous chickens as well as crossbred chickens produced from the indiscriminate cross breeding of imported fast growing birds and local indigenous hens form the bulk of these domestic flocks (Dyubele *et al*., 2010). Domestic chicken production systems, in general, involve dual-purpose lines (meat and eggs), are characteristically low-input production systems and are a means of producing high-quality protein from low-quality feed (Kitalyi, 1998).

Chickens were introduced to South Africa in the early 1600's by the early settlers and traders. These were then crossed with European lines introduced from Europe during the era of African colonisation. Domestic chickens are generally dual purpose types that have not been exposed to artificial selection in informal breeding programs (Van Marle-Köster *et al*., 2009). Although the production potential of domestic fowl is low when compared to commercial broilers, domestic lines are widespread throughout rural Africa and Asia. They have the added advantages of an inherent scavenging and nesting habit, better resistance to disease and have evolved the crucial ability to thrive in harsh nutritional and environmental conditions to which modern broilers are not suited (Hoffmann, 2005; Van Marle-Köster *et al*., 2009).

There is a concern that inbreeding, as a result of uncontrolled mating strategies, and selection for better performance could lead to genetic dilution and a loss of genetic variation within indigenous/domestic lines (Van Marle-Köster *et al*., 2009). In lieu of this, various programs have been put in place to stimulate conservation activities and broach the subject of possible losses in genetic resources on both a local and international scale. The Farm Animal Conservation Trust (FACT), established in 1994, was put in place to highlight the need to conserve native animal genetic resources and led to the development of the 'Fowls for Africa' program (Van Marle-Köster & Casey, 2001; Van Marle-Köster *et al*., 2009).

2.4 Non-commercial Lines of South Africa

"Fowls for Africa", set up by the Animal Production Institute (API) of the Agricultural Research Centre (ARC) at Irene, aims to conserve the native chicken populations found in South Africa and to promote their use and re-introduction to the rural agriculture sector (Van Marle-Köster, 2001). The native lines of chicken that form the conservation population at the ARC (Irene) originated from various rural populations throughout Southern Africa. These include the Potchefstroom Koekoek, Naked Neck, Lebowa-Venda and Ovambu (Ovamboland in Namibia) lines. Other middle-level lines that form part of the conservation populations at ARC include the Black Australorp and New Hampshire lines, introduced to South Africa in 1925 and 1947, respectively. These form part of the conservation program as they are commonly found in rural flocks and are hardy, dual-purpose lines (Van Marle-Köster *et al*., 2009).

2.4.1 Potchefstroom Koekoek

The Potchefstroom Koekoek is a line locally developed by Mr. C.L. Marais at the Research Institute of Animal Husbandry and Dairying, in Potchefstroom. It was developed by the crossing of Black Australorp cockerels with White Leghorn hens and the subsequent mating of the F1 hens and cockerels. The Plymouth Rock was then included in the breeding program with the subsequent registering of the Potchefstroom Koekoek (Fig. 1) as a native line in 1976 (Van Marle-Köster *et al*., 2009). Classified as a heavy line, males can reach 3.5-4.5kg mature weight and the females 2.5-3.5kg. A very popular line, the Koekoek lays large numbers of brown eggs and when slaughtered at the end of its productive life, has an attractive deep yellow meat (Anonymous, 2013).

Named in relation to its colour pattern, the Koekoek has a characteristic black and white speckled plumage. The colouring is a sex-linked trait making gender identification easier; as a result they are very popular in breeding programs. Koekoek chickens possess a sex-linked gene, 'bargene', which gives the males distinguishable light grey bars on the feathers (Figure 1) (Van Marle-Köster & Casey, 2001; Anonymous, 2013).

Figure 1 Potchefstroom Koekoek hen and cockerel (http://edenparadigm.com/tag/koekoek)

2.4.2 Naked-Neck

Recorded as far apart as central Europe and Malaysia, the Naked-Neck (Fig. 2) is believed to have been introduced to South Africa by the early traders from Malaysia (Van Marle-Köster & Casey, 2001; Anonymous, 2013). The unique feature of the Naked-Neck line is a smooth skinned neck and crop area of the breast, totally lacking in feathers (Anonymous, 2011).

When compared to other heavy lines of roughly the same proportion, cocks and hens reaching 3.2-4.0kg and 2.5-3.2kg respectively, the Naked-Neck has 30% less feathers. This is advantageous in a number of ways (Anonymous, 2011; Anonymous, 2013):

- a considerable amount of dietary protein is used in feather production,
- there are less feathers to remove during slaughter resulting in easier passage through the slaughter line, and
- Naked-Necks are more heat tolerant as a result.

Naked-Neck chickens possess a major gene, *Na-,* which causes the 'naked neck' phenotype. Naked-Necks that are homozygous (pure-bred), for the *Na*-gene, have a completely bald neck whilst heterozygous birds have a tuft of feathers on the lower portion of the neck. Naked-Necks occur in a variety of colour patters, with white, red and black combinations (Van Marle-Köster & Casey, 2001).

Figure 2 Naked-Neck hen and cockerel (http://www.wickedfoodearth.co.za/indigenous-poultry-breeds-in-south-africa)

2.4.3 Lebowa-Venda

First recorded in Venda (Limpopo Province) in 1979 by Dr Naas Koetzee, the Lebowa-Venda is associated with two of the largest ethnic groups living in the Northern Province. Similar chickens have subsequently been discovered in the Southern Cape and Qua-Qua region, although the name derived from the original description has been retained (Van Marle-Köster & Casey, 2001; Anonymous, 2011).

The Lebowa-Venda (Fig. 3) is considered a light line with cockerels and hens reaching 2.9-3.6kg and 2.4-3.0kg respectively (Anonymous, 2011). They are a popular line thanks to the bird’s high quality egg production, resistance to disease, and the hens are broody and very good mothers (Anonymous, 2011; Anonymous, 2013).

They are a multi-coloured line with white, black and red as the major colours. Interestingly, these are the major colours that also occur in indigenous cattle and goats (Anonymous, 2011).

Figure 3 Lebowa-Venda hen and cockerel

(http://www.feathersite.com/Poultry/CGP/Venda/BRKVenda.html)

2.4.4 Ovambo

The Ovambo (Fig. 4) are the typical line found in the northern regions of Namibia, with its name referring to their region of origin (Anonymous, 2011; Anonymous, 2013). This line was distinguished by the local Ovambo people as a line of chicken native to the area (Van Marle-Köster & Casey, 2001).

Also considered a light line, the Ovambo line is smaller in stature than the Lebowa-Venda line, with roosters weighing between 1.7-2.1kg and hens 1.24-1.4kg. They are an agile, aggressive line, and have been known to catch and eat small rats and mice. The Ovambo line is also known to roost in trees and have the ability to fly away to avoid predators (Van Marle-Köster & Casey, 2001).

The Ovambo's plumage consists of mostly dark red, brown and black feathering, this in conjunction with its smaller size is believed to camouflage it and protect it from raptors (Anonymous, 2013).

Figure 4 Ovambo hen and cockerel (http://edenparadigm.com/tag/chickens)

2.4.5 Black Australorp

Black Australorps (Fig. 5) in South Africa originated from Australia where they were selectively bred from the production-bred Black Orpington, a purely exhibition line, to a highly successful commercial one (Anonymous, 2011). Introduced in 1925, the Black Australorp is a dual-purpose line, providing large numbers of good brown eggs and a dark textured meat popular with rural consumers (Van Marle-Köster *et al*., 2009). A black Australorp hen holds the world record for eggs produced, producing 364 eggs in 365 days (Dohner, 2010a).

A heavy line, the Black Australorp rooster can weigh as much as 4.6-5.0kg and the hen as much as 3.7-4.2kg. They have an intense blue-black plumage with dark slate-coloured legs and bright red wattles and combs (Dohner, 2010a).

Figure 5 Australorp hen and cockerel (http://www.longmeadowranch.com/Gardens/Egg-laying-Poultry)

2.4.6 New Hampshire

The New Hampshire (Fig. 6) is a successful line established in New Hampshire, U.S.A., from the breeding of Rhode Island Reds. Breeders bred them through continual selection to produce a fast growing bird, with early maturity, and good egg and meat production (Anonymous, 2011). This line was noted for its specialised traits and by 1935 was recognised as a contributor to both the broiler and egg production industries in the U.S.A. (Dohner, 2010b).

The line was first introduced to South Africa in 1947 (Anonymous, 2011). A medium sized line, the New Hampshire roosters and hens can reach 3.5 and 2.5kg respectively (Anonymous, 2011). Naturally considered a dual-purpose line, the New Hampshire produces large, lightly tinted eggs and a plump carcass. Considered a vital, vigorous bird with good mothering instinct, the New Hampshire line adapts well to backyard poultry systems (Dohner, 2010b).

Figure 6 New Hampshire hen and cockerel (https://www.hensforpets.co.uk/products/chickens-sale-hatching-eggs/new-hampshire-red-bantam)

2.5 Growth Performance and Feed Efficiency

The broiler breeder industry follows an age-for-weight strategy, meaning that birds are bred for slaughter to occur at a fixed weight. This accommodates certain market requirements in that chicken products must fall within narrow weight ranges. Through the efforts of the primary breeding companies remarkable progress in growth and feed conversion have been observed in the broiler industry (Emmerson, 1997).

Havenstein *et al*. (2003b) attempted to assess the comparative contributions of breeding and nutrition to the changes that occurred between 1957 and 2001. The two broiler lines compared were the Ross 308 (used to represent 2001 commercial broilers) and the 1957 Athens-Canadian Randombred Control (ACRBC). Their assessment of nutritional contribution to growth rate and feed efficiency was done by feeding the relative broiler lines diets characteristic of 1957 and 2001. It was found that as much as 85-90% of the change seen in broiler growth is a result of quantitative selection practices, with the 2001 Ross 308 strain on the 2001 diet achieving weights 6.0, 5.9, 5.2, and 4.6 times heavier than the ACRBC at 43, 57, 71, and 85 days of age.

The above study highlights the progress made in selecting for improved growth and feed efficiency, but it is not without consequence. Physiological complications including reduced reproductive performance, increased carcass fat and skeletal abnormalities have been linked to intense growth selection (Emmerson, 1997). It has also been shown to have a negative impact on meat quality (Jaturasitha *et al*., 2008b).

Limited data is available on the growth performance and feed efficiency of South African domestic chicken lines (Van Marle-Köster *et al*., 2009). As the demand for poultry meat increases, as well as consumer awareness and health concerns, so the opportunity for alternative poultry systems and the relevance of indigenous poultry increases. In order for these opportunities to be exploited, more information on indigenous poultry growth performance and feed efficiency is needed (Dyubele *et al*., 2010).

Van Marle-Köster & Casey (2001) carried out trials in order to provide base-line data for the domestic species common to Southern Africa, as listed by the 'Fowls for Africa' program. Those included in the trial were: the Potchefstroom Koekoek, Naked-Neck, Lebowa-Venda and Ovambu. Also included was the Cobb commercial broiler which served as a benchmark for comparison. Significant differences were found between the lines for growth up to an age of 77 days (Table 1). Similar feed intake results were obtained for the indigenous lines; the broiler had significantly higher gains and lower feed conversion ratio (FCR). Comparable results were obtained by (Tadelle *et al*., 2003) (Table 2), who examined the growth performance and feed utilization potentials of various Ethiopian domestic lines. The study included the Tilili, Horro, Chefe, Jarso and Fayoumi lines.

Table 2.1 Comparative growth performance and FCR of South African domestic chickens (Adapted from Van Marle-K**ö**ster & Webb (2006))

	Line				
	Koekoek	**Naked-Neck**	**Lebowa-Venda**	**Ovambo**	**Cobb**
Final weight (g)	1114	1062	937	1183	2000
Total feed intake (g)	3680	3720	3390	3610	4100
Feed conversion ratio	3.3	3.5	3.6	3	2

Table 2.2 Comparative growth performance and feed efficiency of Ethiopian domestic chickens (Adapted from Tadelle *et al*. (2003))

Line

	Tilili	Horro	Chefe	Jarso	Fayoumi
Final Weight (g)	-	-	-	-	-
Total Feed Intake (g)	2360.40	2022.80	2409.10	1926.30	3867.90
Feed Conversion Ratio	4.95	5.72	5.20	5.63	5.64

The comparatively poor productivity associated with domestic chickens can mostly be attributed to low standards of management, health care and feeding. It is generally agreed that output could be increased through improved management and nutritional status of the local chicken lines (Demeke, 2003). It should be noted that this stigma is a result of their production being compared to that of commercial broilers. The suitability of indigenous fowl to free range/rural production is often ignored. Despite this and the efforts that have gone into developing intensive poultry production, domestic poultry remain essential to low-income food-deficit countries (Guèye, 2000). Indigenous chickens remain popular as they are highly adaptable, are tolerant to most common diseases, and require minimum input. It is believed that, because genetic change is a function of both within- and between-strain selection (Havenstein *et al*., 2003a), the genetic diversity of indigenous and commercial chickens (exotic lines) could be utilised through cross breeding schemes. Although breeding programs involving indigenous chickens are difficult to implement because of competition with commercial breeding companies (Bekele *et al*., 2010).

2.6 Carcass Characteristics

The poultry industry is seeing a continuing trend in consumer preference from whole birds to further/secondary processed products, although in countries where the use of slow-growing/indigenous lines is developing as the majority is sold as whole birds (Dransfield & Sosnicki, 1999; Zhao *et al*., 2012). After slaughter and primary processing, carcasses can be either packaged and marketed whole or processed further into other forms such as parts or de-boned portions (secondary processing). With an increased preference towards high quality and further processed parts, the poultry industry has had to adjust its marketing strategies to accommodate those changes. Today, the majority of poultry is being marketed in a manner that targets the yield of high value products such as breasts and boneless filets (Young *et al*., 2001). Broiler strains, sex and age at slaughter are generally selected in a manner that maximises profit. This makes it important for poultry manufacturers to anticipate yield patterns (Young *et al*., 2001).

To comply with the demands of the consumers and the slaughter industry, broilers are required to have high slaughter yields and a desirable carcass conformation (Bogosavljevic-Boskovic *et al*., 2010). The poultry carcass can be described as the empty body of the chicken post slaughter, i.e. that which is used for eating purposes or further processing. There are numerous configurations that can be obtained when processing a chicken carcass and the portions produced are usually dependent on the value of the cut which is in turn dependent on consumer preference (Owens *et al*., 2000). The yield of edible parts can be described as the relative contributions of portions, namely the breast, leg (drumstick), thigh and wing, to the total carcass weight. This is usually represented as a percentage of the carcass weight. In short, carcass composition is effectively described by the dressing %, portion percentage yields, and dissection characteristics of the portions.

It has been stated that the success of the poultry industry is highly dependent on the ability of producers to increase the proportions of the most relevant parts of the carcass; this includes increasing breast muscle yield and reductions of carcass fat (Guerrero-Legarreta, 2010). Havenstein *et al*. (2003a) highlights the changes that have occurred in broiler carcass composition. Secondary processing (see # 2.6.2) is a consequence of the modern lifestyle and with it a shift towards less disposable time and more disposable income. It has been found that as a result of these trends, today's consumers are willing to accommodate and pay extra for the convenience and partial preparation of the product (Owens *et al*., 2010). This trend toward secondary processing has highlighted the possible negative aspects of fast growth as well as the short falls of indigenous chickens with respect to portion yield and total lean muscle yield.

2.6.1 Portion Yields and Dissection Characteristics

Poultry carcass composition is mostly affected by line and feeding system, two factors that have also been shown to affect meat quality (Jaturasitha *et al*., 2008b). Growth rate changes are generally associated with changes in carcass composition and yield (Havenstein *et al*., 2003a). According to (Havenstein *et al*., 2003a), the breeding of meat-type broilers has resulted in a doubling of the percentage yield of breast meat since the early 1990's.

In addition to supplying the consumers with a comparatively cheap protein source, the rise of the South African broiler industry as the country's largest individual agriculture industry can be attributed to the industry's response to the needs of consumers and food service operators with regards to secondary processing (Esterhuizen, 2011). This response has resulted in an emphasis being placed on the improvement of breast meat yield and muscle mass development (Table 3) (López *et al*., 2011). This trend can be seen when comparing the dressing % and breast yields of broilers and indigenous birds (Tables 3 and 4).

Table 2.3 Broiler dressing% and portion yields (% of carcass weight)

Line	Dressing %	% Breast	% Thigh	% Leg	% Wing	Source
Broiler Male	74.50	20.40	22.84	-	-	
Broiler female	74.34	19.88	21.13	-	-	(Raji *et al*., 2010)
Ross 308 Male	71.41	20.80	12.51	10.16	-	
Ross 308 Female	71.91	21.65	12.80	9.51	-	(Anonymous, 2007)

There is limited data available on the carcass characteristics and portion yields of South African domestic chicken lines. Van Marle-Köster & Webb (2006) evaluated the carcass characteristics of South African domestic birds (the Potchefstroom Koekoek, New Hampshire, Naked-Neck, Lebowa-Venda and Ovambo chicken lines) and compared them to that of a commercial broiler line. The birds were grown to an age of 11 weeks (77 days) and maintained on a commercial broiler diet after which ten birds from each line were randomly selected for analyses. The highest dressed carcass mass was obtained by the Ovambo (939.8g) whilst the Naked-neck had the highest breast muscle yield (18.03%). Similar results were obtained by (Jaturasitha *et al*., 2008a; Jaturasitha *et al*., 2008b; Hagan & Adjei, 2012).

Table 2.4 Indigenous chicken dressing% and portion yields (% of carcass weight)

Line	Dressing %	% Breast	% Thigh	%Leg	%wing	Source
Naked-Neck	74.45	16.3	28.5	5.1	10.3	(Hagan & Adjei, 2012)
Black-boned	63.7	16.6	20.6	16.7	-	
Thai Indigenous	65.9	17.7	19.6	16.7	-	
Bresse	63.6	18.6	20.4	16.6	-	
Rhode Island Red	64.4	16.1	19.3	17.6	-	(Jaturasitha *et al*.,

2008b)

2.6.2 Value Adding

Secondary processing, also known as "value-added" processing, is advantageous in that it provides more choice for the consumer as well as means for the producer to add value to the product. There are numerous configurations to be obtained from the secondary processing of chicken carcasses, thus providing the producer with the opportunity to satisfy different markets. An example of this would be the preference of some Asian cultures towards cuts that allow a minimal amount of hand contact during eating (Owens *et al*., 2010). This also results in some portions having a greater value depending on market trends and consumer preference. Secondary processing is the fastest growing segment in the poultry industry (Rogers, 1992). Following consumer preference trends, the production of broilers towards carcass qualities such as high breast muscle yield has become an important focus for both producers and processors. As far back as 1995 less than 10% of poultry products sold in the United States were whole birds (Young *et al*., 2001).

2.7 Meat Quality

The transformation of muscle into meat after slaughter is characterised by *rigor mortis* and the pH changes within the muscle, and their ultimate effect on meat quality (Guerrero-Legarreta, 2010). Meat quality in general is considered an extremely complex topic that can be approached from different points of view. When evaluating meat quality it is important to assess carcass conformation characteristics as well as good aesthetic, sensory and nutritional characteristics (Bogosavljevic-Boskovic *et al*., 2010). Although substantial progress has been made in broiler growth and efficiency of growth, a general failure to include selection for meat quality parameters has resulted in the appearance of abnormalities in meat products such as PSE (pale, soft, and exudative) and DFD (dark, firm, and dry) (Souza *et al*., 2011).

The selection practiced by commercial broiler breeders for traits such as fast growth rate and increased breast muscle yield have often been assumed to negatively impact on the eating quality of broiler meat and on skeletal and cardiovascular well-being of the live bird (Sandercock *et al*., 2009). Sandercock *et al*. (2009) showed that genetic variation for appearance traits was moderately high and suggested that differences seen were most likely the result of selection for broiler traits. The slower growth rate and higher activity of indigenous chickens may contribute to differences in the properties of their meats (Wattanachant *et al*., 2004). Slower growing birds have been shown to be more popular as a result of a firmer texture and more intense flavour (Castellini *et al*., 2008). This can be seen in the systems employed in rearing French Label Rouge hybrids. Due to a slower growth rate and largely cereal based diet they have been shown to have 10% more muscle development, resulting in a firmer textured and darker coloured meat with more desirable flavour, and a roughly 15% decrease in both inter- and intramuscular fat (Bogosavljevic-Boskovic *et al*., 2010). The differences seen in meat quality between indigenous chickens and conventional broilers are predominantly related to colour, flavour, and texture (Souza *et al*., 2011).

2.7.1 Physical Characteristics

There is limited data available on the meat quality and the physical characteristics of indigenous poultry (Van Marle-Köster & Webb, 2006; Sandercock *et al*., 2009). This is a result of a general lack of information about the underlying genetic and physiological factors affecting it or the effects that genetic selection for broiler or layer traits has on carcass conformation, muscle and/or meat quality (Van Marle-Köster & Casey, 2001).

2.7.1.1 Colour

The importance of tissue colour cannot be underestimated, it is the first characteristic noticed by consumers when deciding whether or not to buy a meat product (Fanatico *et al*., 2007). This becomes particularly important when considering further processed products such portioned chicken pieces and de-boned fillets; products will often be rejected by consumers based on whether or not the colour varies from the expected norms. It has been reported that dramatic colour variations do occur in the production of boneless and skinless raw breast meat (Qiao *et al*., 2001).

Consumers will tend to consider two different preferences when purchasing meat products, the first being the appearance of the meat and the second the palatability, which is ultimately determined by the overall quality of the meat (Kropf, 1980). Taking this into consideration, consumers have few if any means of determining the quality of the meat and hence must make a decision on whether or not to purchase the product based on how the product appears to the naked eye (Kropf, 1980). The appearance of meat is affected by a number of factors making it a complex topic when regarding meat quality. It involves animal genetics, *ante*- and *post-mortem* conditions, muscle chemistry and a number of factors related to meat processing and packaging (Mancini & Hunt, 2005).

2.7.1.2 Colour Measuring System

There are short comings associated with visual colour perception. These include factors such as differing colour sensitivities from person to person, varying environments, and a difficulty to communicate and document colour and colour differences. The problems associated with human colour perception can only be solved through the use of colour instrumentation with an internationally specified colour system, thus guaranteeing an objective description of coloured objects. This is because humans measure colour as a composite, whilst instruments measure colour reflection at individual wavelengths (Owens *et al*., 2010).

The system that is widely used today is the CIELAB/CIE L*a*b* system. Developed in 1976, the CIELAB colour scale provides a standard, approximately uniform colour scale that may be used by everyone allowing colour values to be more easily compared. It consists of two axes a* and b* denoting the red/green and yellow/blue values, respectively, as well as a third axis, L*, representing lightness. The system allows any colour to be specified according to the coordinates L*, a* and b*.

Colour measurements in the +a* direction depicts a shift toward red and in the +b* direction depicts a shift toward yellow. L* is measured from 0-100 with 0 denoting black or total absorption (Honikel, 1998).

2.7.1.3 Poultry Meat Colour and pH Effects

It has been suggested that there is a positive correlation between selection for faster growth and the production of lighter coloured breast meat (Lonergan *et al*., 2003). Consumers will tend to reject a poultry product that differs from the expected pale tan to pink colour of raw meat and pale to grey of cooked meat (Fletcher, 2002).

Poultry meat colour is affected by a number of factors (Fletcher, 2002):

- haem pigments (myoglobin),
- pre-slaughter factors including genetics, feed, hauling and handling, and stress, and
- post-slaughter factors including stunning techniques, muscle pH changes and further processing.

Differences in growth rate as well as age of slaughter may result in differences in meat appearance, texture, and composition (Lonergan *et al*., 2003; Castellini *et al*., 2008). The production system used is an important factor in terms of meat colour, meat of animals raised 'free-range' and allowed to forage will tend to be darker than that of animals raised in a confined/enclosed space and fed concentrate feeds (Sañudo *et al*., 2007). The high stocking densities and selection associated with commercial production have reduced bird activity, resulting in various carcass and meat defects (Mead, 2004).

Muscles are classified based on the relative proportions of red and white muscle fibres. Red (slow-twitch) muscle fibre has large amounts of myoglobin in comparison to white muscle fibre (fast twitch). The high myoglobin content allows greater oxygen storage and results in the red colour associated with dark poultry meat (Owens *et al*., 2010). It has been found that among broilers of a similar age, the darker meat of larger birds had better flavour, was more tender and received overall higher sensory scores that that of smaller birds, thus suggesting that growth rate has an effect on colour and quality of chicken meats (Mead, 2004).

Myoglobin is the primary protein affecting meat colour, with haemoglobin and cytochrome C also playing a role, and is affected by species, muscle and age of the bird (Mancini & Hunt, 2005; Fanatico *et al*., 2007). 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*., 2007; Tlhong, 2008).

An inseparable relationship between muscle pH and colour is widely accepted (Mancini & Hunt, 2005). Post-mortem pH changes play a key role in controlling the functional qualities of meat with a sharp drop in pH being associated with quality defects such as the PSE (pale, soft and exudative) syndrome (Castellini *et al*., 2008). Ultimate pH of the muscle directly influences the capacity of myoglobin to express the red colour in meat and its ability to bind water (Souza *et al*., 2011). The post-mortem muscle pH decline is determined by the glycolytic enzyme activity in the muscle with the ultimate pH being determined by the levels of glycogen reserves present in the muscle post slaughter (Fanatico *et al*., 2007). A strong negative correlation between muscle pH and lightness values and a positive correlation between pH and redness (a*) have been demonstrated (Lonergan *et al*., 2003). The pH of muscle at slaughter is roughly neutral (7.0), but as glycogen present in the muscle is broken down the pH falls, to an ultimate pH of between 5.8 and 5.4 at roughly 24 hours post slaughter (Heinz & Hautzinger, 2007).

Souza *et al*. (2011) compared the physical-chemical characteristics of two strains of broiler utilized for semi-intensive rearing with those of the Cobb® broiler. Ultimate pH values were found to be very similar, thus accounting for the similar lightness (L*) values between treatments. Redness (r*) and yellowness (b*) were higher in the Cobb® meat samples.

Other authors have also found lower pH in slower growing birds when compared to the fast growing broilers. In contrast to (Souza *et al*., 2011), Berri *et al*. (2001) studied the effect of selection for increased growth performance and improved body composition on meat quality in relation to post-mortem pH decline and muscle biochemistry, and found that the breast meat of lines selected for fast growth was paler (higher L* values) and less red (lower a* values) than that of non-selected lines. Similarly, Sandercock *et al*. (2009) found that broilers had breast muscle that was lighter, and less red and yellow in colour than that of the slower growing layer and traditional lines.

2.7.2 Chemical Composition

The increase in demand for healthy and natural foods has favoured organic livestock farming. 'Modern' consumers perceive the meat from animals that have been produced in alternative production systems (organic) as safer due to the presumed absence of chemical residues (Mead, 2004). The demands and expectations of the modern consumer are a result of their being more scientifically informed and this has put pressure on the various supply chains within the industry to supply this information (Mead, 2004). A higher guarantee of the absence of residues within organic meats is well documented, but the ultimate effect of organic production systems on the qualitative characteristics of organic production systems is not well known (Castellini *et al*., 2002).

Meat is composed of muscle, connective tissue, fat and bone. Around 75% of muscle is made up of water, and 20% protein, with the remaining 5% constituting fat, carbohydrates, and minerals (Adeyanju *et al*., 2013). The meat from poultry tends to vary in composition between species. Chickens have both light and dark meats (caused by different muscle fibres) which differ in nutrient profile, contributing to differences in nutrient profile within species. Factors that may affect within species differences include line, diet and feeding, environment, and processing (Owens *et al*., 2010).

2.7.2.1 Proximate Analysis

The method used for the quantitative analysis of the nutritional profile of meats is proximate analysis and it is the simplest way of assessing the most important features representing a meat's composition. Proximate analysis is used to quantify the relative levels of (Hui, 2012):

- moisture
- crude protein (nitrogen)
- ash
- crude lipid/fat
- carbohydrate

The water content of muscle varies depending on the muscle being sampled, the kind of meat being analysed and the pH trends of the meat sample (Adeyanju *et al*., 2013). The rate of pH decline or lack thereof also has an impact on the water holding capacity of the meat sample. Sharp declines in pH are generally associated with meats that have a lower water binding capacity in contrast to meats with a small decline in pH that tend to have a much higher water binding capacity (Heinz & Hautzinger, 2007). The effect of pH on water binding capacity is an important factor concerning meat quality as the presence of the moisture based defects PSE and DFD can have detrimental effects when concerning the cooking and eating quality of the meat (Heinz & Hautzinger, 2007).

The protein content of chicken meat is variable, ranging from 16-24% (Owens *et al*., 2010). The nutritional value of a meat product is closely linked to the content of high quality proteins, which are characterized by their content of essential amino acids. The myofibrillar proteins present in muscle, myosin and actin, are said to be of the highest biological value due to their high concentrations of essential amino acids (roughly 65%) (Heinz & Hautzinger, 2007). The myofibrillar proteins are involved in the contractile functioning of the muscle (Lawrie, 1998).

Fat content has the largest influence on muscle composition, with general fatness of the animal playing a large role (Hui, 2012). Fat occurs as both intra- and extra-muscular fat, and contributes largely to the flavour and juiciness of the meat (Adeyanju *et al*., 2013). Despite the presence of subcutaneous fat layer, this is often ignored when conducting proximate analysis as consumers will tend to remove the fat and skin of chicken products prior to cooking. The carcass characteristics of livestock and the factors that influence the accumulation, distribution and composition of fat has been extensively studied although the role, value and perception of animal fat differs significantly between the various role players in the meat industry (Webb & O'neill, 2008). There is generally an inverse relationship between moisture and intramuscular fat content, as moisture increases so fat decreases, and vice versa (Owens *et al*., 2010).

Ash represents the mineral portion constituting roughly 1% of the muscle composition and is primarily represented by the elements potassium, phosphorus, sodium, chlorine, magnesium, calcium and iron (Hui, 2012). Muscles will tend to contain roughly the same amount of carbohydrate (1%) which is represented primarily by glycogen ante-mortem and lactic acid post-mortem, although the contribution of carbohydrate is generally assumed to be zero (Owens *et al*., 2010).

Little information regarding the chemical composition of South African indigenous chickens is available, (Van Marle-Köster & Webb, 2006) analysed the chemical composition of the breast muscle from several strains of South African indigenous chickens (Table 5).

Table 2.5: Proximate composition (%) of South African domestic poultry adapted from Van Marle-Köster & Webb (2006)

Line	Moisture	Crude Protein	Crude Fat	Ash
Koekoek	64.60	16.32	10.09	1.38
New Hampshire	64.10	14.94	13.06	1.34
Naked-Neck	64.10	16.00	12.35	1.38
Lebowa-Venda	68.60	17.56	10.20	1.66
Ovambo	61.50	15.86	12.74	0.96
Cobb	65.60	14.12	14.37	0.85

2.7.2.2 Fatty Acids

Meat has often been criticized as a food that is high in fat and that has an undesirable balance of fatty acids (Wood & Enser, 1997). An increased awareness of the health benefits of foods has resulted in the application of ways to improve/change the lipid content and fatty acid composition of the foods we eat. Chicken meat is known to contain high levels of protein and have a lower fat content and is considered a good source of beneficial polyunsaturated fatty acids (PUFA). It has also been shown that the PUFA content of poultry meat can be manipulated through the levels of these fats in poultry diets (Coetzee & Hoffman, 2002; Yang *et al*., 2010).

In all animal species it is possible to change the fatty acid composition via diet but even more so in the case of single stomached (monogastric) animals such as pigs and chicken. It has been recommended that daily fat intake of humans be reduced to 30% of total energy intake with a total intake of 10% of energy intake for saturated fatty acids (SFA). A lot of emphasis has been placed on the ratio of PUFA to SFA. It is thought that this ratio should be increased to above 0.4 (Wood *et al*., 2004).

Fatty acid composition has various 'technological' effects on meat quality (Wood *et al*., 2004):

- Due to different melting points, variation in fatty acid composition has an effect on the texture of the inter- and intramuscular fat of meat
- Fat colour is affected by fatty acid composition
- The ability of unsaturated fatty acids to rapidly oxidise has an important effect on shelf life (the rate at which the quality of the meat deteriorates with regards to rancidity and colour deterioration), as well as flavour development during cooking.

As of late there has been a focus on the type of PUFA found in the meat and the subsequent balance of n-6:n-3 PUFA. This ratio is believed to be a risk factor in the incidence of cancers and coronary heart disease, notably in the formation of blood clots (Wood *et al*., 2004). According to (Wood *et al*., 2004), the ratio of n-6:n-3 PUFA can also be influenced/manipulated through dietary means. This is because dietary fatty acids are absorbed into the tissues of monogastric animals with little modification to their structure resulting in the potential for manipulation of the fatty acid profile of poultry tissue (Coetzee & Hoffman, 2002). Lopez-Ferrer *et al*. (1999) compared the effects of varying levels of fish oils, linseed oil and tallow, and found that the supplementation of fish oils increased tissue n-3 PUFA significantly.

Dietary induced fatty acid profile changes of chicken meat can be induced by the inclusion of Linoleic (LA) and Linolenic (LNA) acids, vegetable oils, fish oils, and fish meal. More significant changes in the fatty acid profile of meats are gained when supplementing feed with marine fats than vegetable fats. The differences seen when comparing marine and vegetable fats are a result of the high but variable levels of eicosapentaenoic acid (C 20:5 n-3, EPA) and docosahexaenoic acid (C 20:6 n-3, DHA) within marine oils (Lopez-Ferrer *et al*., 1999). Although the effects of fish oils on tissue FA have been found to be more significant, their use is limited by their effect on the sensory quality of the meat with high quantities resulting in a fishy taint (Ratnayake *et al*., 1989).

Very few studies have focused on the fatty acid profile of indigenous chickens in South Africa and data is scarce. In the study previously mentioned, Van Marle-Köster & Webb (2006) quantified the carcass characteristics of several domestic chickens and a broiler line. The broiler line had the highest fat content and, the Koekoek and Lebowa-Venda lines had the lowest fat content. Carcass fatty acid composition differed significantly between lines (Table 6).

Table 2.6 Carcass Fatty Acid Composition of SA Indigenous Chickens

	Fatty Acids						
	14:0	**16:0**	**16:1**	**18:0**	**18:1**	**18:3**	**20:1**
Koekoek	1.05	24.58	7.92	8.23	45.28	12.18	1.54
New-Hampshire	0.85	25.83	9.85	7.74	44.27	10.12	1.92
Naked-Neck	1.15	25.10	8.19	7.82	42.74	12.87	2.34
Lebowa-Venda	1.29	22.17	7.98	6.99	45.06	14.44	2.05
Ovambo	0.92	23.71	9.23	6.07	46.68	12.72	1.33
Cobb	0.92	26.62	8.78	8.37	43.11	9.58	2.42

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Growth Performance of Slow-growing Chicken Lines Commonly Found in South Africa

3.1 Abstract

This trial investigated whether differences would be observed for growth performance of four slow-growing chicken lines commonly found in South Africa. Two slow-growing lines developed outside South Africa, the Black Australorp and New-Hampshire, two native lines including the Naked-Neck and Potchefstroom Koekoek, as well as a hybrid between a Cobb 500 broiler and Potchefstroom Koekoek were evaluated. Fifty birds of each line were randomly allocated to cages of five birds per cage. The birds were fed a standard broiler diet *ad libitum* and grown to an average weight of 2kg. Weekly live weights were measured in conjunction with feed intake. Average daily gain (ADG), feed conversion ratio (FCR), and European Production Efficiency Factor (EPEF) were calculated and analysed for line differences. No significant differences were observed between the indigenous lines with regards to feed intake ADG (~22g), FCR (~3.65), and EPEF (~57). The Hybrid outperformed the indigenous lines for all parameters measured.

3.2 Introduction

There is an ever increasing demand for meat and other livestock products. This increase is related to an increasing population, income growth and urbanisation, and can be seen on a global scale (Sandercock *et al*., 2009). A similar pattern can be seen in the poultry industry, the South African broiler industry has grown an average of 4% per year over the last decade. It contributes to almost 17% of the total gross value of agricultural products and is the largest individual agricultural industry worth a gross value of around R27 billion (Kreamer, 2013). The commercial broiler industry is dominated by international; developed-country based and vertically integrated companies. With rising income, people have become more willing to spend a larger portion of their money on animal protein which has resulted in an increase in the consumption of meat and dairy products (Guèye, 2000). The South African GDP (Gross Domestic Product) per capita increased from 4866.92 USD/49498.50 Rand for the year 2004 to 6003.46 USD/61057.60 Rand for the year 2012 (Anonymous., 2012b), resulting in higher disposable income.

Domestic chickens have long been associated with rural households and have an important socio-economic role to play in poor communities. Domestic fowl have also provided a way of converting available feed-stuffs around the rural setting into highly nutritious and well-appreciated products (meat and eggs) (Mtileni *et al*., 2011). Historically, the domestication of fowl was primarily for cultural and religious purposes. Originating from the Red Jungle Fowl (*Gallus gallus*) in the east, chickens were introduced to other parts of the globe leading to the development of specific regional types (Van Marle-Köster, 2001). Introduced to South Africa in the early 1600's, most likely by early settlers and traders from Europe and sub-Saharan Africa, chickens have become an integral part of rural communities (Van Marle-Köster *et al*., 2009; Mtileni *et al*., 2011). Constituting up to 80% of total poultry numbers in rural African countries, indigenous birds are a valuable asset to local rural populations as they contribute greatly to food security and poverty alleviation (Guèye, 2000; Hoffmann, 2005).

The commercial broiler industry has had to adjust its strategies to accommodate the increased consumer demand for animal protein. It has done this through technological advances in animal production and processing (value-added products) (Hoffmann, 2005). Significant progress has been made in the broiler industry to improve broiler growth and feed efficiency thanks to breeding companies that specialize in applying quantitative genetics to the selection of chickens bred specifically for meat consumption (Havenstein *et al*., 2003). Modern breeding practices have resulted in a broiler that can reach market weight in as little as 5 weeks (Anonymous, 2012a). Havenstein *et al*. (2003) found that in a comparison of the broiler strain characteristics of broilers raised in 1957 and those of a modern line, the modern broiler had a 4- to 5-fold increase in body weight and an improvement in feed efficiency of 15 to 20%. Modern broilers are expected to reach a live weight of 2kg in 35 days, with a cumulative feed intake of 3.3kg and feed conversion ratio (FCR) of 1.6 (Anonymous, 2007). This progress is directly linked to the desire to improve the economic results of rearing meat type chickens (Połtowicz, 2012).

Modern-day changes in the consumer preference towards products that are more naturally produced have resulted in a renewed interest being placed on domestic chickens (Dyubele *et al*., 2010). Despite this renewed interest, the use of indigenous chicken lines in commercial production is limited by their lower production potential when compared to that of commercial lines. Generally dual-purpose lines, indigenous chickens have the advantage of being hardy, highly adaptive, and suited to free-range production (Van Marle-Köster *et al*., 2009). In addition to the improvement seen in commercial broiler production, poultry production has been diversified by the use of various genetic types to meet different consumers' preferences. Some countries are seeing a trend towards alternative production systems using intermediate or slow-growing lines (Duclos *et al*., 2007). In order to promote the production of indigenous birds, information on their production performance, meat quality and carcass characteristics is essential (Dyubele *et al*., 2010). The objective of this study was to quantify the growth and feed efficiency of South African indigenous chickens in order to evaluate their potential to satisfy niche markets. This is necessary as the fast-growing lines associated with commercial broiler production are not suited to the conditions prevalent in alternative production systems and little information is available on the production potential of the slow-growing lines commonly found in rural South Africa.

3.3 Materials and Methods

Birds and housing system:

For the purpose of this trial two South African indigenous lines (Potchefstroom Koekoek and Naked-Neck, two slow growing lines developed outside South Africa (Black Australorp and New Hampshire), that are commonly used in backyard poultry systems, as well as a commercial broiler Koekoek hybrid were chosen. All four indigenous lines feature on the 'Fowls for Africa' program set up by the Agricultural Research Council (ARC) who identified several lines that have adapted to survive the harsh conditions in South Africa associated with free-range rural production. The lines chosen included:

- Potchefstroom Koekoek,
- New Hampshire,
- Naked-Neck,
- Black Australorp and
- Broiler x Koekoek hybrid

The birds were hatched onsite at Stellenbosch University's Mariendahl Poultry Experimental farm located near Stellenbosch, Western Cape Province, South Africa. Fifty day-old chicks, of each line, were randomly allocated to pens at a stocking rate of five birds per pen, sexes were not separated. Day old chicks were housed in the Bioassay brooding units for the first two weeks after which they were moved to the grow-out facility, Kuikenhuis C. There the birds were grown out in raised pens of 0.9 x 0.6m, at a density of five birds per pen until completion of the growth trial at an average weight of 2kg (age - # Table 3.1).

Treatment and diets:

Treatment went according to line. The birds were supplied with a standard commercial broiler diet for the duration of the trial at a rate of 900g starter, 1.2kg grower and then finisher until completion of the trial at a live weight of 2kg. A commercial broiler diet was used to represent the standard of feed and formulation currently available for extensive chicken farming as there is no feed specifically formulated for un-selected, slow-growing birds. At the end of the grow-out period twenty roosters of each line were slaughtered according to standard commercial practice. The birds were stunned by using a manual stunner at 50-70 Volts, 0.2 ampere, for 5-10 seconds followed by manual exsanguination before evisceration and further processing (Chambers & Grandin, 2001).

Measurements and statistical analysis:

The chickens were supplied with feed and water *ad libitum.* Feed intake was measured on a weekly basis and was determined by weighing the initial amount of feed offered, feed added and the feed remaining in the feeders at the end of the weekly weighing periods. Initial chick weights (day 1) were recorded before placement of the chicks. Body weight of the birds was then measured weekly thereafter until slaughter. Individual weights were calculated as an average of the pen total weight.

From the data obtained during the trial, feed conversion ratio (FCR) (Equation 3.1), average daily gain (ADG), European production efficiency factor (EPEF) (Equation 3.2) (Boling-Frankenbach *et al*., 2001; Awad *et al*., 2009), and feed intakes (FI) were calculated.

Equation 3.1

$$Feed\ coversion\ ratio\ (FCR) = \frac{Cumulative\ Feed\ Intake\ per\ Chicken\ (g)}{Average\ Live\ Weight\ per\ Chicken\ (g)}$$

Equation 3.2

$$European\ Production\ Efficiency\ Factor (EPEF) = \frac{Liveability\ (\%) \times Live\ Weight\ (g)}{Age\ (days) \times FCR} \times \frac{100}{1}$$

Data were analysed using SAS software, version 9.3 of the SAS system for windows (Statistical Analysis System, Version, 9.2, 2006, SAS Institute Inc., CARY, NC, USA). Line effects on EPEF and FCR were analysed by means of One-way ANOVA GLM Procedure with the main effect being line. The model for the experimental design is indicated by the following:

$$y_j = \mu + \beta_j + \varepsilon_j$$

The terms are defined as; the overall mean (μ), the effect of line and the error associated with the lines (ε_{jk}).

Average daily gain and weekly FI were calculated by means of a regression analysis. An analysis of covariance was done to determine line differences where the intercept from the individual ADG linear regression function was included as a covariable. Bonferroni *post hoc* tests were used throughout to calculate least square means. For all interpretations a 5% probability level was used to determine significance (P<0.05). Data were analysed using SAS software, version 9.3 of the SAS system for windows.

3.4 Results

Results for production parameters are shown in Table 3.1. The data obtained during the performance analysis showed no differences (P<0.05) for EPEF as pertaining to the indigenous lines (Table 3.1). The Hybrid differed (P<0.05) from the indigenous lines with a higher EPEF of 154.28. The same trend was seen with ADG over the entire growth period, with the Hybrid showing higher gains (P<0.05) when compared to the indigenous birds which did not differ (P>0.05) when compared to each other (Table 3.1). The mean live weight, as represented in Table 3.1, is the average weight of each line at the conclusion of the growth trial. The FCR achieved by the indigenous chickens did not differ (P>0.05). The best performance with regards to FCR was achieved for the Hybrid with an FCR of 2.37.

Table 3.1 Means (± s.e.) for Slaughter age, European production efficiency factor (EPEF), average daily gain (ADG) (g/day), live weight (g), and feed conversion ratio (FCR) of South African indigenous chickens reared in raised pens

Treatment (Line)	**Slaughter Age (days)**	**ADG[1]**	**FCR[2]**	**Live Weight**	**EPEF[3]**
Australorp	$93^{a} \pm 2.05$	$22.81^{a} \pm 0.37$	$3.58^{a} \pm 0.16$	$1978.4^{a} \pm 40.53$	$62.92^{a} \pm 5.81$
New-Hampshire	$92^{a} \pm 2.19$	$21.76^{a} \pm 0.39$	$3.74^{a} \pm 0.18$	$1777.6^{a} \pm 44.39$	$57.43^{a} \pm 5.81$
Koekoek	$93^{a} \pm 2.19$	$21.30^{a} \pm 0.38$	$3.88^{a} \pm 0.18$	$1870.6^{a} \pm 44.39$	$52.71^{a} \pm 5.81$
Naked-Neck	$93^{a} \pm 2.37$	$21.94^{a} \pm 0.45$	$3.61^{a} \pm 0.16$	$1832.9^{a} \pm 40.53$	$54.20^{a} \pm 5.81$
Hybrid	$62^{b} \pm 2.37$	$35.03^{b} \pm 0.43$	$2.37^{b} \pm 0.20$	$2246.6^{b} \pm 35.73$	$154.30^{b} \pm 4.74$

[a,b]Means within columns with different superscripts differ significantly (P<0.05)

[1] ADG (Average Daily Gain: g/day)

[2] FCR (Feed conversion ratio: g feed/g body weight)

[3] EPEF (European Performance Efficiency Factor)

Weekly average live weight, weekly feed intake (weekly FI), and cumulative feed intake (cumulative FI) are presented in Figures 3.1, 3.2 and 3.3, respectively. The blue (Hybrid) and red (slow-growing lines) arrows indicate the change from the starter diet to grower diet (1) and then the grower to finisher diets (2): each line was fed a fixed amount of starter and grower diets (900g and 1200g respectively). The trends with regards to average live weight followed the same pattern as that of ADG, with no significant differences seen between the indigenous birds. The Hybrid grew significantly faster ($P<0.05$) with a higher ADG of 35.03g/day (Table 3.1). This trend can also be seen when looking at the average live weight at each weighing period (Figure 3.1). This also resulted in the Hybrid having a higher ($P<0.05$) mean live weight at day of slaughter (Table 3.1)

The weekly feed intakes (weekly FI) of the indigenous chickens did not differ ($P>0.05$) for the first 70 days of the growth phase (Figure 3.2). At day 77 the Naked-Neck line had lower ($P<0.05$) intakes (609.37g) compared to the remaining indigenous lines (~740g), after which the intakes remained similar until completion of the trial. Weekly intakes of the Hybrid were higher ($P<0.05$) than those of the indigenous birds until day 28. Weekly intakes were then similar ($P>0.05$) for all lines from day 35-49. Thereafter for the remainder of the Hybrid growth phase until day 63, weekly intakes were higher ($P<0.05$) compared to those of the indigenous lines.

Cumulative FI recorded for the indigenous birds was similar ($P<0.05$) when compared to each other throughout the growing period (Figure 3.3). Cumulative FI at day 28 saw the Hybrid (1191.2g) showing higher ($P<0.05$) cumulative intakes than the Naked-Neck (711.7g) and New-Hampshire (884.7g) lines. At day 49 cumulative intake for the Hybrid (3179.8g) was higher ($P<0.05$) than that of the Naked-Neck line (2239.4g). At day 56 cumulative intake for the Hybrid (4147.8g) was higher ($P<0.05$) than that of the Naked-Neck (2785.1g) and New-Hampshire (3235.4g) lines.

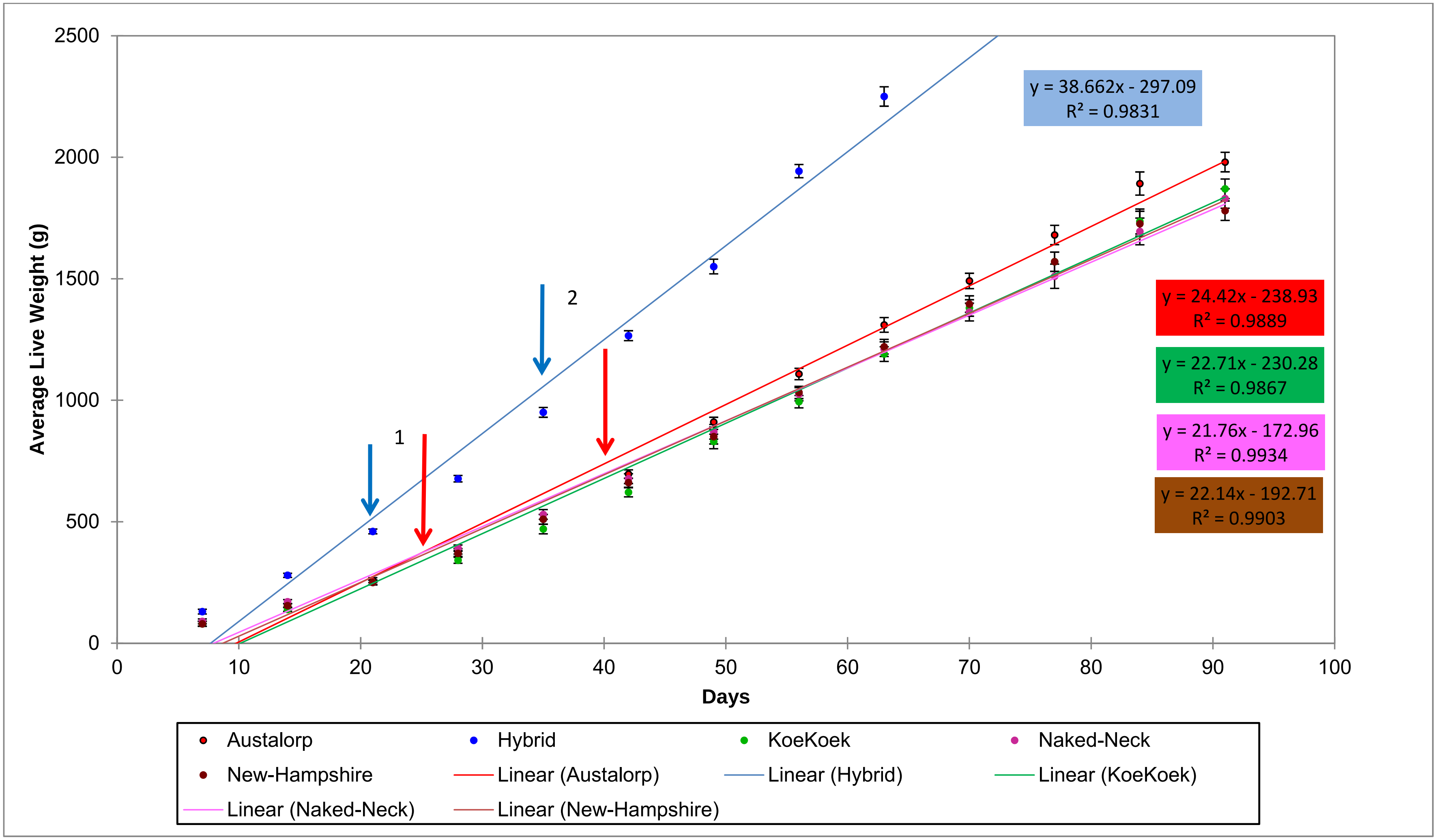

Figure 3.1 Weekly average live weights per bird of South African indigenous chickens raised to an average weight of 2kg on a broiler ration

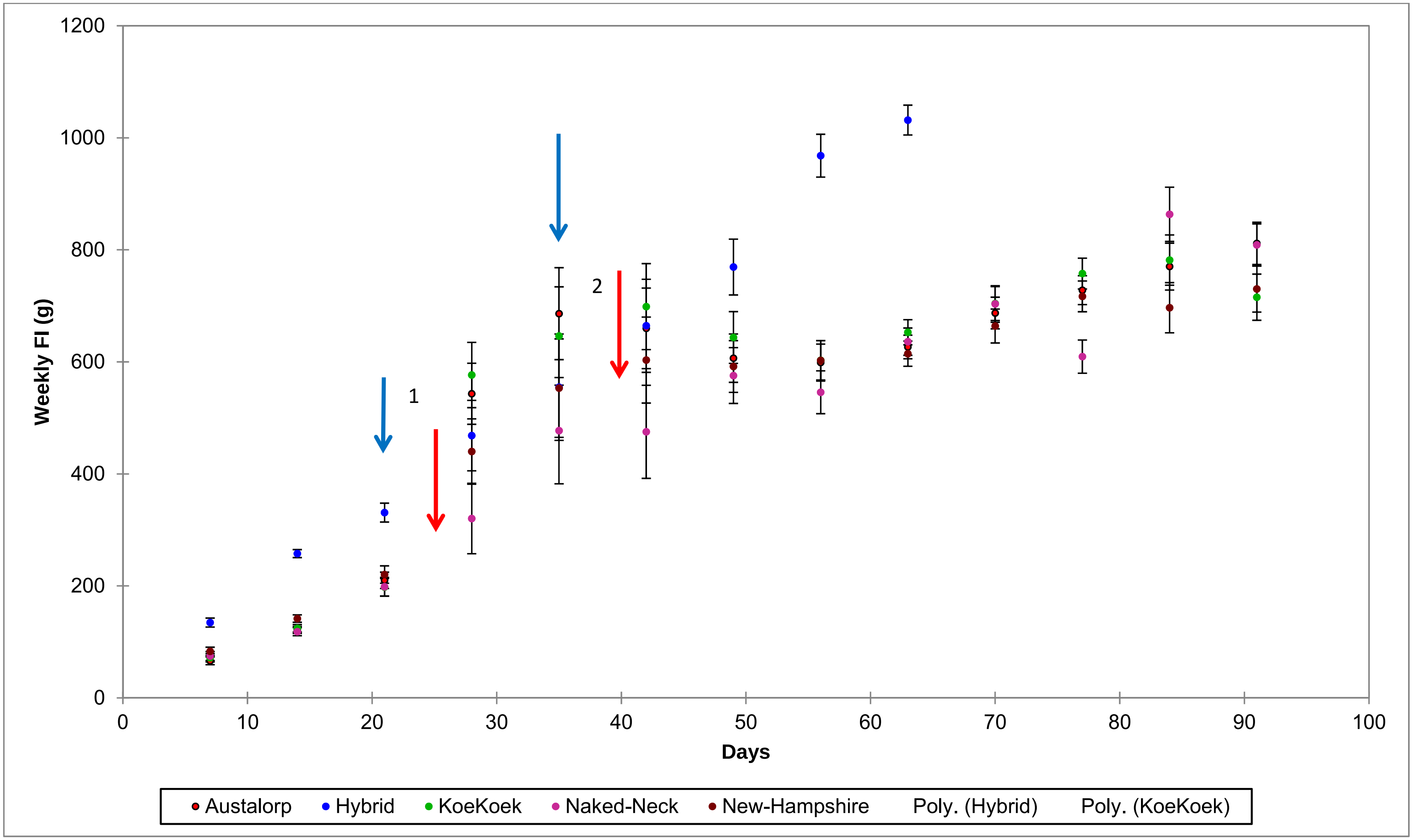

Figure 3.2 Weekly feed intakes (Weekly FI) per bird of South African indigenous chickens raised to an average weight of 2.0kg on a broiler ration

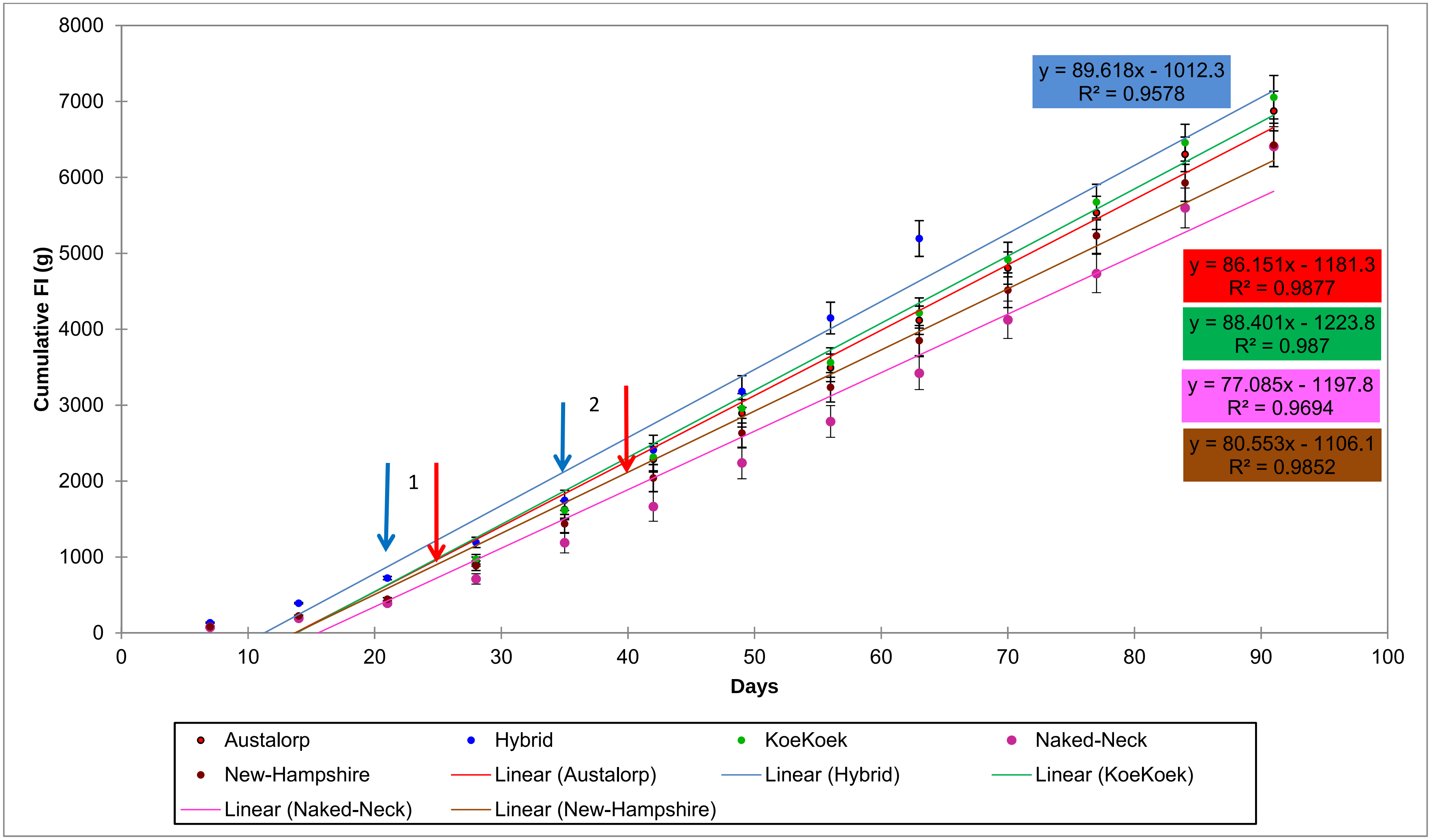

Figure 3.3 Weekly cumulative feed (Cumulative FI) intakes per bird of South African indigenous chickens raised to an average weight of 2kg

3.5 Discussion

Indigenous chickens are associated with low productivity, but this is when being compared to the performance obtained by commercial broiler lines, which have been bred over numerous generations for fast growth and efficient feed usage (Fanatico, 2005a). At 35 days, the Cobb 500 broiler line is expected to have a mass of 2.067kg with an FCR of 1.566 g feed/g body weight (Anonymous, 2012): a FCR less than half of that obtained by the indigenous lines used in this trial (~3.70) (Table 3.1).

The indigenous chickens had significantly lower EPEF scores (Table 3.1), roughly 25% of what one would expect from a commercial broiler. According to (Butcher & Nilipour, 2002), a broiler under ideal conditions should put on weight at an average of ±50 grams a day with an EPEF of ±260. Mean live weight (Table 3.1) of the Hybrid was higher ($P<0.05$) than that of the indigenous chickens; this can be explained by the rapid growth (ADG = 35.05g) of the Hybrid compared to that of the indigenous birds (ADG ~22g). Although the Hybrid performed significantly better than the Indigenous lines, their performance was still significantly lower than that of commercial broilers. Intermediary results were observed for the Hybrid birds, with production values roughly half way between those of the indigenous lines used for the purposes of this trial and those projected for the Ross 308 and Cobb 500 Performance Objectives (Anonymous, 2007; Anonymous, 2012a). When regarding EPEF, ADG, and FCR it must be noted that the time taken for the Hybrid to reach the target weight of 2kg was significantly shorter than that of the indigenous birds (Slaughter age - Table 3.1).

The intermediary gains of the Hybrid seen are most likely explained by the effects of heterosis not being enough to exceed the gains made through commercial selection practices. However, the results obtained during the course of this trial for the indigenous lines compared well with those from previous trials involving local and international indigenous chicken lines (Van Marle-Köster & Casey, 2001; Fanatico *et al*., 2005; Youssao *et al*., 2012).

Weekly intakes for the indigenous lines varied dramatically, notably during the periods where the diets were changed from starter to grower and then grower to finisher (Figure 3.2). In the days following the change from the starter to the grower diet (day 25 for the indigenous lines) there is a dramatic increase in feed intake which is more notable for the indigenous lines. The dramatic increase in feed intake seen after day 25 can most likely be attributed to the commercial grower diet not satisfying the metabolic needs of the chickens for that stage of growth. The genetic differences between commercially bred broilers and indigenous poultry are mostly associated with differences in growth rate and muscle development

(Summers & Leeson, 1985). Subsequently, their nutritional needs differ. The balance of essential amino acids and the balance of dietary energy to amino acid content of the commercial diet provided are likely to have been suboptimal with regards to suiting the metabolic needs of the indigenous chickens (Summers & Leeson, 1985). According to Summers & Leeson (1985), both an increase and decrease in feed intake has been associated with diets that have an imbalance in essential amino acids, with the response being dependent on the severity of the imbalance. Marginal deficiencies are associated with chickens overeating. In addition to this, broiler grower diets are higher in energy and lower in protein than starter diets, possibly resulting in the indigenous chickens consuming more to satisfy their protein needs. The change in diet was more suited to the Hybrid which is made apparent when looking at the linear increase in weekly feed intake compared to the indigenous lines (Figure 3.2).

3.6 Conclusion

The results from the trial highlight the vast difference in production performance when comparing indigenous/exotic lines to broiler strains or their hybrids. On growth performance alone, the potential of these indigenous lines as an intensive produced agricultural product is put into question. The feed conversion ratio was almost twice that what one could expect from a commercial broiler. Without the development of niche markets, the production of indigenous birds would be far too expensive and drawn out to warrant commercial production under intensive production systems.

This is not to say the potential of developing niche markets is out of the question; in Thailand the meat of indigenous chickens is considered a delicacy. Grown to the same slaughter weight as broilers, the meat of Thai indigenous chickens is preferred due to its unique flavour and firmer texture. In 2008, 22.4% of chickens produced in Thailand were native or Thai indigenous birds (Wattanachant *et al*., 2004; Wattanachant, 2008). Despite their slower growth rate, indigenous chickens have the advantage in that they can be raised with minimal input and low production costs. They can also be raised outdoors/free range, a concept that is growing in popularity when regarding the ethical demands of some modern consumers as pertaining to the welfare of the animals that produce the meat they consume. From the results of this study it has become evident that further research needs to be done in order to formulate specific diets that suit the nutritional demands of the slower-growing lines. By doing so the cost of production of the indigenous lines could be optimised.

3.6 References

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Chapter 4

Carcass Yield and Characteristics of Slow-growing Chicken Lines Commonly Found in South Africa

4.1 Abstract

This study describes the carcass characteristics of four slow-growing chicken lines (#chapter 3) (the Black Australorp, New-Hampshire, Naked-Neck and Potchefstroom Koekoek) as well as a hybrid between the Koekoek and Cobb 500 broiler. The study involved raising 50 birds from each line to an average weight of 2kg with *ad libitum* access to a commercial broiler feed and water. Thereafter 20 cockerels from each line were selected for slaughter. The heaviest chilled carcass weight was recorded for the Australorp which was significantly heavier than the Naked-Neck and Koekoek chickens. No significant differences between lines were observed for dressing %. The breast yield obtained by the Hybrid was significantly higher (45.56%) than that of the indigenous lines which had similar breast yield values (~41%). Significant differences were seen for thigh and drumstick yield. The Naked-Neck had the highest thigh yield and the lowest drumstick percentage yield, 27.7% and 17.3% respectively. For thigh yield the New-Hampshire, Koekoek and Naked-Neck lines had higher ($P<0.05$) yields (~27%) than the Hybrid (25.45%). A similar pattern was observed for drumstick yield with the Australorp, New-Hampshire and Koekoek lines having higher ($P<0.05$) yields than those of the Hybrid. For the tissue characteristics, similar ($P>0.05$) values were found for breast skin (~20%), breast bone (~22%), drumstick skin (~4.3%), and drumstick muscle (~27%). The Hybrid had higher ($P<0.05$) breast muscle, thigh muscle and total muscle percentage yield (22.67%, 26.17% and 43.51%, respectively).

4.2 Introduction

The consumption of white meat, such as chicken meat, has grown in popularity and is considered superior to red meat with regards to its health aspects (Jaturasitha *et al*., 2008b). The industry is also experiencing a continuing trend towards further processed products. This is seen as a consequence of a modern lifestyle which has resulted in a shift towards less disposable time and more disposable income. People are thus willing to spend more money for the convenience of having products partially prepared for them (Owens *et al*., 2010).

To comply with the demands of the consumers and the slaughter industry, broilers are required to have a high slaughter yield and desirable carcass conformation (Bogosavljevic-Boskovic *et al*., 2010). Secondary processing is seen as a way for producers/processors to add value to the product and provide the consumer with more choice. It also allows producers to satisfy specific niche markets (Owens *et al*., 2010).

Changes in chicken growth rates are generally associated with changes in carcass composition, both of which are affected by line and feeding system (Havenstein *et al*., 2003). As a result, performance criteria such as growth velocity and muscle mass have dominated decision making as broiler breeding has focused on least cost production. This approach however has come under scrutiny due to the appearance of morphological abnormalities in the skeletal muscles of fast growing lines (Dransfield & Sosnicki, 1999), abnormalities thought to be brought about by the muscle fibres being pushed to their maximum size constraints (Dyubele *et al*., 2010). The past two decades has seen an increase in the yields of edible meat and a doubling in the percentage yield of breast muscle (Havenstein *et al*., 2003).

As consumer interests in organic and free-range products increases so the need to identify lines suited to the systems required for free-range production becomes necessary. The yield of breast meat is of the most interest as consumers tend to prefer white meat over dark meat. In the study of Fanatico *et al*. (2005b) the impact of line and outdoor access on the carcass characteristics of a slower-growing broiler strain and fast-growing broiler strain were assessed. The fast-growing lines had higher breast percentage yields with and without outdoor access, although the fast-growing lines had a lower proportion of leg and wing portions. This is most likely a result of the fast-lines being selected for increased breast yield resulting in a decrease in the relative yield of other portions. Alternatively it could be because the slow-growing lines were more active (Fanatico *et al*., 2005b). The outdoor treatments also resulted in a higher dressing % whilst the slow-growing lines had a lower ratio of white to dark meat which is indicative of the genetics of slower growing birds being geared towards a higher level of physical activity and its subsequent effects on muscle deposition (Fanatico *et al*., 2005b). Raji *et al*. (2010) quantified the dressing %, breast, thigh, and fat yields of broiler males and females indoors and obtained results comparable to those of (Fanatico *et al*., 2005b).

Worldwide the relevance of indigenous chickens has increased; this has been prompted by an increasing demand for natural/organic meat that has been produced with the minimal use of additives and chemicals (Dyubele *et al*., 2010). The production of chickens in free-range facilities may provide meat traits sought by consumers such as those related to colour, flavour and texture. The differences seen in these quality traits are believed to be related to differences in growth rate and muscle development; the latter are also strongly linked to genetics (Souza *et al*., 2011). Although, the effect of different genetic strains on the various meat quality parameters is not fully understood (Souza *et al*., 2011).

Little information is available on the carcass characteristics of South African indigenous chickens. Van Marle-Köster & Webb (2006) showed that South African indigenous chickens are 2.5 times less efficient as pertaining to production criteria than commercial/exotic lines, when reared under intensive conditions, taking about 4 months to meet market weight requirements. Although slower growing, the advantage of a slower growth rate and less intensive fattening is a leaner carcass, a more desirable poultry carcass composition (lower fat, higher protein) as well as a more desirable proportion of retail cuts (Jaturasitha *et al*., 2008a). Similar results on the indigenous chickens for carcass breast muscle content were observed by Safalaoh *et al*. (1996) and Van Marle-Köster & Webb (2006). The purpose of this study was to describe and quantify the carcass characteristics of South African slow-growing chickens in order to assess their suitability for production in alternative production systems.

4.3 Materials and Methods

Birds and housing system:

For the purpose of this trial four slow-growing lines (# chapter 3) commonly found in rural South Africa as well as a commercial broiler Koekoek hybrid were chosen. The lines chosen included:

- Potchefstroom Koekoek (KK)
- New Hampshire (H)
- Naked-Neck (NN)
- Black Australorp
- Broiler x Koekoek hybrid (X)

Treatment went according to line. The trial was conducted onsite at Stellenbosch University's Mariendahl Poultry Experimental Farm located near Stellenbosch, Western Cape Province, South Africa. Fifty birds of each line were randomly allocated to pens at a stocking rate of five birds per pen, sexes were not separated. The birds were grown out in raised pens of 0.9m x 0.6m at a density of five birds per pen until completion of the trial.

Treatments and Diets:

The birds were supplied with a standard commercial broiler diet for the duration of the trial (see Chapter 3 for details on production parameters). Feed and water were supplied *ad libitum*. At the end of the growth period, 20 cockerels from each line were slaughtered of electrical stunning (20 Volts, 0.2 ampere, 5-10 seconds) followed by manual exsanguination.

Measurements and statistical analysis:

Live weight at slaughter (LWS) was recorded. After primary processing (evisceration, head, foot, and feather removal) the hot carcass weight (HCW) was recorded. The carcasses were then refrigerated at 4ºC (24 hours) and the chilled carcass weight (CCW) recorded. Dressing % was then calculated as follows:

Dressing % $= (CCW/LWS) \times \frac{100}{1}$

Portion yields were then calculated as a percentage of CCW after the carcass was halved and divided into the commercial portions breast, thigh, drumstick and wing using a portioner. The thighs and drumsticks were removed from the half carcass by cutting above the thigh towards the acetabulum and behind the pubic bone. The thighs and drumsticks were separated by cutting perpendicular to the joint between the drumstick and thigh bones. The wings were then removed by cutting the joint between the scapula and coracoid. The right side portions were then further dissected to obtain the relative yields of muscle, skin and bone and are expressed as a percentage of the portion yield. All portions and yields were weighed and the results recorded. After which they were vacuum-packed and frozen at -18°C for further analyses. From the data obtained during the slaughter, LWS, CCW, dressing %, percentage yield of commercial cuts, and the dissection characteristics were analysed.

The effect of line on the above parameters were analysed by means of one-way ANOVA. Bonferroni *post hoc* tests were used throughout to calculate least square means. For all interpretations a 5% probability level was used to determine significance (P<0.05). Data were analysed using SAS software, version 9.3 of the SAS system for windows (Statistical Analysis System, Version, 9.2, 2006, SAS Institute Inc., CARY, NC, USA).

4.4 Results

The results for live weight at slaughter (LWS), chilled carcass weight (CCW), dressing % and the relative contributions of the different portions are presented in Table 4.1. Differences were observed for LWS (P<0.05), it must be noted though that LWS is the average weight of cockerels selected for slaughter and does not represent the average live weight including hens (# Chapter 3, Table 3.1). The CCW of the Australorps at 1534.3g was higher (P<0.05) than that of the Koekoek, Naked-Neck and New-Hampshire. No differences (P>0.05) were obtained for dressing % (~65%) between the different indigenous lines and the Hybrid.

Table 4.1 Means (± s.e.) for live weight and carcass yield of the major portions of South African indigenous chickens reared in raised pens to an average weight of 2kg

	Treatment (Line)				
	Australorp	**New-Hampshire**	**Koekoek**	**Naked-Neck**	**Hybrid**
LWS[1]	2400.1^{a} ± 298.32	2056.2^{c} ± 193.81	2360.5^{ab} ± 182.63	2137.7^{c} ± 258.41	2157.8^{bc} ± 269.15
CCW[2]	1534.2^{a} ± 48.65	1399.6^{abc} ± 41.05	1343.5^{c} ± 26.28	1381.7^{bc} ± 40.2	1527.4^{ab} ± 31.12
Dressing%	64.6 ± 0.48	64.8 ± 0.46	65.3 ± 0.40	64.6 ± 0.47	64.6 ± 0.46
Retail cuts (% of chilled carcass weight)					
Breast	41.9^{b} ± 0.39	40.7^{b} ± 0.37	40.5^{b} ± 0.41	41.5^{b} ± 0.93	45.6^{a} ± 0.32
Thigh	25.4^{b} ± 0.31	26.4^{ab} ± 0.27	26.6^{ab} ± 0.36	27.7^{a} ± 0.9	25.5^{b} ± 0.31
Drumstick	18.9^{a} ± 0.3	18.8^{a} ± 0.24	18.4^{ab} ± 0.22	17.3^{c} ± 0.31	17.4^{bc} ± 0.17

[a,b]Means within rows with different superscripts differ significantly (P<0.05)

[1]Live weight at slaughter (LWS)

[*2]Chilled carcass weight (CCW)

Breast yield of the Hybrid was higher (P<0.05) (45.6%) than that of the indigenous lines which had similar yields (P>0.05) (~41%). The thigh yield of the Naked-Necks, at 27.7%, was higher (P<0.05) than that of the Hybrid and Australorp, 25.5% and 25.4%, respectively. Drumstick yields followed a similar pattern with the indigenous birds generally obtaining a higher yield, the Australorp (18.9%) and New-Hampshire lines (18.8%) both had yields higher (P<0.05) than that of the Hybrid (17.4%).

The relative contribution of muscle, skin and bone to the portions (percentage of breast, thigh and drum) are depicted in Table 4.2. The yield of breast muscle of the Naked-Neck (41.4%) and Hybrid (45.3%) was higher (P<0.05) than that of the other lines. The Koekoek had the lowest contribution of breast muscle at 34.6%. Although the proportion of thigh muscle among the indigenous birds was similar (P>0.05), the hybrid thigh muscle yield was higher (P<0.05) than that of the Koekoek. No differences (P>0.05) were seen for the proportion of drumstick muscle.

Table 4.2 Means (± s.e.) for the muscle, skin and bone from the retail cuts (expressed as a percentage of portion weight) and the total contribution of muscle, skin and bone to the chilled carcass weight of South African indigenous chickens

	Treatment (Line)				
	Australorp	**New-Hampshire**	**Koekoek**	**Naked-Neck**	**Hybrid**
Breast					
Muscle	$35.1^{b} \pm 0.9$	$36.2^{b} \pm 1.34$	$34.6^{b} \pm 0.84$	$41.3^{a} \pm 1.42$	$45.3^{a} \pm 0.66$
Skin	11.3 ± 0.64	12.3 ± 0.42	12.5 ± 0.6	10.6 ± 0.5	10.5 ± 0.50
Bone	46.4 ± 1.76	46.2 ± 1.16	44.0 ± 1.24	45.3 ± 2.02	43.5 ± 1.00
Thigh					
Muscle	$50.1^{ab} \pm 1.8$	$51.4^{ab} \pm 1.54$	$47.2^{b} \pm 1.14$	$50.8^{ab} \pm 0.92$	$52.3^{a} \pm 1.08$
Skin	$14.3^{ab} \pm 1.02$	$11.9^{bc} \pm 0.86$	$15.5^{a} \pm 0.9$	$8.0^{d} \pm 0.36$	$9.1^{cd} \pm 0.44$
Bone	$33.9^{bc} \pm 2.36$	$37.4^{ab} \pm 1.66$	$31.1^{c} \pm 1.14$	$41.2^{a} \pm 1.86$	$35.8^{abc} \pm 1.4$
Drumstick					
Muscle	53.5 ± 1.12	55.8 ± 1.48	53.8 ± 0.9	55.5 ± 0.9	54.8 ± 0.48
Skin	9.2 ± 0.68	9.0 ± 0.38	8.7 ± 0.34	8.4 ± 0.4	8.2 ± 0.28
Bone	$32.6^{bc} \pm 1.08$	$31.5^{c} \pm 1$	$32.6^{bc} \pm 0.92$	$37.1^{a} \pm 0.92$	$36.1^{ab} \pm 0.6$
Total[#]					
Muscle	$37.7^{c} \pm 0.8$	$38.8^{cb} \pm 0.68$	$36.2^{c} \pm 0.61$	$40.5^{b} \pm 0.67$	$43.5^{a} \pm 0.65$
Skin	$10.0^{a} \pm 0.44$	$9.8^{ab} \pm 0.38$	$10.8^{a} \pm 0.33$	$8.0^{c} \pm 0.37$	$8.4^{bc} \pm 0.36$
Bone	$34.3^{ab} \pm 1.06$	$34.6^{ab} \pm 0.91$	$32.3^{b} \pm 0.81$	$36.7^{a} \pm 0.88$	$35.2^{ab} \pm 0.86$

[a,b]Means within rows with different superscripts differ significantly (P<0.05)

[#]Expressed as a percentage of CCW

No differences (P>0.05) were seen for breast and drumstick skin yield between the different chicken lines. However, differences (P<0.05) were seen for the skin yields of the thighs with the Koekoek having the highest proportion of skin (15.5%) and lowest proportion of bone (31.1%). Differences (P<0.05) for the proportion of bone in the drumsticks were also observed between lines. The hybrid (36.1%) and Naked-Necks (37.1%) had the highest drumstick bone yield.

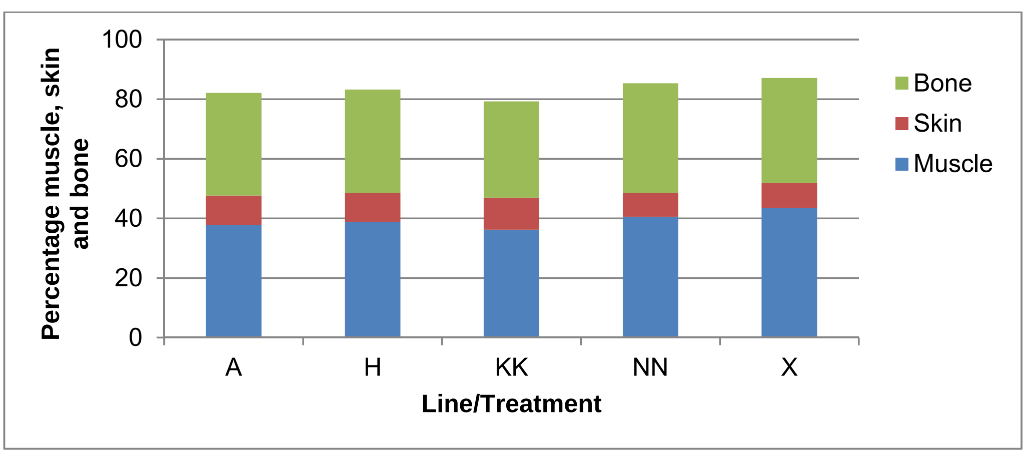

Figure 4.1 Total muscle, skin and bone of South African indigenous chickens raised on a commercial broiler diet expressed as a percentage of chilled carcass weight (A- Australorp, H- New-Hampshire, KK- Koekoek, NN- Naked-Neck, X- Hybrid)

The relative contributions of total muscle, skin and bone of the portions measured as a percentage of CCW are presented in Table 4.3 and Figure 4.1. The total contribution of muscle, skin and bone does not add up to 100% as the neck weight, wing weights and tail weight were included in the measurement of CCW and not that of the dissected portions. The Hybrid had higher (P<0.05) total muscle yield when compared with the indigenous chickens. Total skin yield of the Koekoek and Naked-Neck chickens differed (P<0.05). The Koekoek had the highest total skin yield at 10.8%. Differences (P<0.05) were also observed for total bone yield with the Naked-Neck chickens having the highest yield, 36.8%, and the Koekoek the lowest, 32.3%. Similarly, the Neck-Neck also had the highest yield of bone (36.8%) which was significantly higher (P<0.05) than that measured for the Koekoek (32.3%).

4.4 Discussion

Although there were slight differences between the CCW of the Hybrid, Australorp, Naked-Neck and New-Hampshire, of more interest is the dressing% of the different lines as this parameter takes into account the variation in LWS. Although there were differences in LWS (which were most probably due to the sampling procedure), the dressing% did not differ between lines. Although the dressing % obtained by the indigenous lines in this trial (~64.5%) are substantially lower than those projected for broilers slaughtered at a weight of 2kg (~71.1%) (Anonymous, 2007; Anonymous, 2012), the results compared favourably with those of other studies involving indigenous chickens (Jaturasitha *et al*., 2008a; Jaturasitha *et al*., 2008b; Islam & Nishibori, 2009). The differences seen in dressing% between indigenous chickens and commercial broilers is a direct result of the selective breeding practices employed by commercial breeders that are geared towards increased muscle yield (Jaturasitha *et al*., 2008a).

This reasoning can also be applied to the differences seen for portion yield between the indigenous chickens raised in this trial and the Hybrid, and is indicative of the aims of modern broiler breeding practices being focused towards a higher output in the proportion of retail cuts, notably focusing on breast production (Hoffmann, 2005). Consumer research and technology in the early 1990's showed a trend in consumer preference towards boneless, skinless breast meat as it is fast cooking, has perceived health benefits and is sold at a desirable price (Haley, 2001). The higher proportion of thigh and drumstick noted for the indigenous chickens is most likely a result caused by the slower growth rate and less-intensive fattening exhibited by non-selected indigenous poultry, ultimately leading to a higher proportion of the other retail cuts, thigh and drumstick (Khantaprab *et al*., 1997).

Although the main aim of broiler breeding companies is to increase the lean muscle yield of modern chicken lines, focus should also be placed on the skin yield. Skin and skin fat, including subcutaneous fat, can represent as much as 11-15% of total carcass weight (Ferrini *et al*., 2008). This is of importance in the poultry industry as poultry meat is known for being low in fat, with the vast majority of fat being deposited subcutaneously (Fanatico *et al*., 2007). With a growing awareness of human health and nutritional concerns, consumers have become more willing to spend money on products that are perceived as healthier. This has led to the development of specialty markets for poultry produced in alternative systems such as free-range and organic. Chickens raised in alternative systems, that support a slower growth rate, have been shown to have higher muscle protein and lower intramuscular and subcutaneous fat, factors which are thought to be related to increased physical activity and genetics (Havenstein *et al*., 2003; Fanatico *et al*., 2007).

Ultimately, it is the total muscle yield of the whole chicken that is of importance to the commercial producer, and it is when considering this that the total contribution of muscle, skin and bone to CCW becomes relevant. Of the indigenous lines studied in this trial, the Naked-Neck had the highest proportion of lean muscle (40.58%) and the lowest proportion of skin (8.04%). It is difficult to compare the results obtained in this study with those in literature as little research has been done with regards to quantifying the carcass characteristics of indigenous chickens in South Africa and the methods employed in the processing of the carcasses either differ or are unknown. Haque *et al*. (1999) studied the growth performance and meat yield characteristics of Native Naked-Necks in Bangladesh and their crosses with exotic lines grown and found similar patterns to those obtained in this trial. The results obtained were approximately ten percentage points lower throughout, most likely because the birds were slaughtered at a younger age (12 weeks) resulting in a lower dressing % and a lower yield of commercial/retail cuts.

4.5 Conclusion

In the current study the Hybrid outperformed the indigenous birds for dressing % and breast yield, a result influenced by generations of broiler selection by the commercial breeder. The fast growth of the organic food industry, roughly 20% per annum in the United States (Fanatico *et al*., 2005b), although no data could be sourced for the size of this sector in South Africa, has resulted in a focus towards lines that are suited to the conditions prevalent in free-range agriculture. Modern broilers, although having a desirable carcass yield and fast turnover (fast growth and high breast yield) are not always suited to free-range systems (Fanatico *et al*., 2005a). The development of lines that can flourish in minimum input systems such as those associated with free-range agriculture and backyard production systems would go a long way towards promoting free-range agriculture. There has been considerable success in this regard with the systems employed for the 'French Label Rouge' programs. Slower growth and free-range access has resulted in lower carcass fat and an improvement in muscle development (Bogosavljevic-Boskovic *et al*., 2010).

Judging from the results obtained in this trial; of the indigenous lines, the Naked-Neck shows the most promise with regards to the proportions of lean muscle and skin for all three portions (breast, thigh and drumstick). The Naked-Necks obtained higher proportions of breast muscle as well as total lean muscle, two factors that have been the main focus of broiler breeders. As with the production parameters (# Chapter 3), the Hybrid generally outperformed the indigenous birds, obtaining significantly higher lean muscle proportions and relatively low skin proportions. Much like the 'French Label Rouge' programs, the use of hybrids in free-range/organic systems in South Africa needs to be further researched.

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Chapter 5

Meat Quality and Composition of South African Indigenous Chickens

5.1 Abstract

The current study aimed to quantify the meat quality characteristics (pH, colour, proximate chemical composition and fatty acid composition) of four slow-growing chicken lines (# chapter 3) (the Black Australorp, New-Hampshire, Naked-Neck and Potchefstroom Koekoek), as well as a hybrid between the Koekoek and Cobb 500 broiler. The study involved raising 50 birds from each line to an average weight of 2kg with *ad libitum* access to a commercial broiler feed and water. Thereafter 20 cockerels from each line were selected for slaughter. Significant differences (P<0.05) were seen for ultimate pH (pH_u) with the Naked-Neck (5.85 and 6.09) and Hybrid (5.83 and 6.02) finishing with the highest pH_u for both the breast and thigh samples, respectively. This corresponded with differences (P<0.05) in colour for all the portions measured (breast, thigh and drumstick). The Naked-Necks' and Hybrids' muscles were darker, showing higher scores for both b* and chroma throughout, whilst the Australorps' muscles were generally lighter showing lower scores for the colour parameters a*, b* and chroma for all three portions. The proximate chemical composition of the breast samples did not differ (P>0.05) between lines. Differences (P<0.05) were recorded for thigh moisture, protein and ash: the Naked-Neck recorded the lowest moisture (72.3%) and the highest protein (18.6%) and ash (1.1%) values. Differences were recorded for drumstick moisture protein and fat: the highest moisture content was measured for the Hybrid (75.9%) and the lowest for the Naked-Neck (73.6%). The indigenous lines had a higher protein content (~19.5%) when compared to the Hybrid (18.9%). The drumstick fat content for the Naked-Necks (4.4%) was higher than the remaining lines. Differences were observed for fatty acid profile. The relative contributions of total SFA and MUFA did not differ (P>0.05) between lines. Total PUFA differed (P<0.05) with the Australorp (28.2%) showing the highest proportion. The ratio of polyunsaturated and saturated fatty acids (P:S), the proportion of n-6 fatty acids and the ratio of n-6/n-3 did differed (P<0.05). The proportion of n-3 fatty acids did not differ (P>0.05). From the study it was evident that line differences for meat quality do exist.

5.2 Introduction

It is widely agreed that the competitiveness of developed food markets is strongly linked to the ability to develop new products that are able to exploit different consumer segments due to the fact that consumer preferences differ (Grunert *et al*., 2004). There is also an increasing demand for products that are perceived as naturally produced (organic) without the excessive use of additives and chemicals, as a result the organic food market has grown by 20% annually for the past decade (Fanatico *et al*., 2005; Dyubele *et al*., 2010). This is a result of a growing awareness of human health and nutritional concerns leading to niche markets for livestock produced in alternative systems.

Appearance, texture and composition all contribute to the overall consumer acceptance of poultry and other meat products. Numerous studies have assessed the impacts of anti- and post-mortem environmental factors that have significant effects on the qualitative characteristics of poultry meat, although little is known about the impacts of the various genetic factors affecting poultry meat quality (Lonergan *et al*., 2003). Substantial progress has been made with regards to growth and feed efficiency in broiler production, although there has been a general failure to include selection for meat quality parameters (Souza *et al*., 2011). It has often been assumed that these selection practices have negatively impacted on the eating quality of chicken meat and the cardiovascular well-being of the bird (Sandercock *et al*., 2009).

The primary characteristic noticed by consumers when regarding whether or not to buy a meat product is the tissue colour. The trend towards selling/purchasing parts and further processed products, such as chicken pieces and de-boned fillets, has resulted in a need to highlight meat quality defects as focus has shifted towards the quality aspects as opposed to the quantity of meat yielded from a carcass (Fanatico *et al*., 2007). Consumers will tend to reject meat products based on whether or not the colour varies from the expected norms (Qiao *et al*., 2001). Pale poultry meat has also been linked to poor functionality in further processing (Fletcher, 1999). PSE-like (pale, soft and exudative) defects in poultry meat are related to accelerated post-mortem muscle metabolism caused by rapid post-mortem muscle pH decline (Berri *et al*., 2001; Qiao *et al*., 2002b). It has been established that the ultimate pH influences the structure of myofibrils, and consequently the colour of meat (Dyubele *et al*., 2010). Barbut (1996) observed a significant negative correlation between meat colour and muscle pH: fillets with darker colour had significantly higher ultimate pH values.

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. In contrast, Berri *et al*. (2001) showed that commercially selected broilers had higher protein content and lower moisture content in the breast muscle. Meat from poultry tends to vary in composition between lines as well as between muscle types. Light and dark meats differ in nutrient profile mostly due to the relative contributions of the different muscle fibre types, fast- and slow-twitch. It is believed that differences in growth rate and level of physical activity result in differences in the meat composition, both among lines and the different muscle types (Lonergan *et al*., 2003; Chuaynukool & Siripongvutikorn, 2007)

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 when compared to the diets on which we as humans evolved. A very high ratio of n-6/n-3 fatty acids have been shown to promote disease whilst a higher ratio of n-3 fatty acids has been shown to suppress disease and is essential to normal growth and development (Simopoulos, 2000; Simopoulos, 2002). For this reason the n-3 group of polyunsaturated fatty acids is considered one of the most important fatty acid groups.

The effect of diet on the fatty acid composition of the animal carcass has potentially become one of the most important fields of study in animal nutrition and meat science. It has become evident that there is an imbalance in the human dietary intake of the various types of fatty acids (Coetzee & Hoffman, 2002). Monogastric animals absorb and deposit dietary fatty acids without significant changes to their structure, and it has subsequently been shown that there is considerable potential to manipulate the tissue fatty acids of these animals through the diet (Coetzee & Hoffman, 2002). Line and production system have been shown to influence meat quality and composition. Although fatty acid profile is largely influenced by diet (Coetzee & Hoffman, 2002), different growth intensities as a result of line may still affect the fatty acid profile (Jaturasitha *et al*., 2008).

The success of the French *Label Rouge* program in Europe, despite a higher retail price, is evidence of the shift in preference towards ‘greener’ poultry production (Fanatico *et al*., 2005). Birds raised in the systems employed by the French *Label Rouge* program have been shown to have 10% more muscle development resulting in a firmer textured, darker coloured meat with more desirable flavour and less inter- and intramuscular fat (Bogosavljevic-Boskovic *et al*., 2010). It has been shown that meat obtained from different chicken lines, ages and muscle types results in differences in their properties, for example the breast and leg muscles of indigenous chickens possess a firmer texture, particularly after cooking (Chuaynukool & Siripongvutikorn, 2007). There is an increased interest in the development of broiler strains that provide birds with features that resemble those of slow-growing lines suited to alternative production systems with the aim of reducing the incidence of biochemical meat abnormalities currently associated with broiler strains reared in conventional commercial systems (Souza *et al*., 2011). The aim of this study was to quantify the meat quality characteristics of South African indigenous chickens in order to assess their potential to fill a niche market for slower-growing lines raised in alternative production systems such as free-range.

5.3 Materials and methods

Birds and housing system:

For the purpose of this trial four slow-growing chicken lines commonly found in South Arica (# chapter 3) as well as a commercial broiler Koekoek hybrid were chosen. All four lines feature on the 'Fowls for Africa' program set up by the Agricultural Research Council (ARC) who identified several lines that have adapted to survive the harsh conditions associated with free-range rural production. The lines chosen for this investigation include:

- Potchefstroom Koekoek (KK),
- New Hampshire (H),
- Naked-Neck (NN),
- Black Australorp (A) and
- Broiler x Koekoek hybrid (X)

Fifty day-old chicks, of each line, were randomly allocated to pens at a stocking rate of five birds per pen, sexes were not separated. The birds were reared in an environmentally controlled facility. The unit comprises of a temperature controlled room equipped with 120 metabolic wire cages measuring 0.9m x 0.6m each containing one tube feeder and two nipple drinkers. Artificial lighting was provided at a pattern of 18 hours of light altering with 6 hours of darkness. Ventilation in the house was set to provide a minimum of six air changes per hour. The chicks had *ad libitum* access to feed and water during the duration of the experimental period.

Treatment and diets:

Treatment went according to line. The birds were supplied with a standard commercial broiler diet at a rate of 900g starter, 1.2kg grower and then finisher until completion of the trial at a live weight of 2kg. Bird weights and intakes per cage were recorded weekly. At the end of the grow-out period roosters were selected from the middle weight group (per pen) and were slaughtered according to standard commercial practice using a process of electrical stunning (20 Volts, 0.2 ampere, 5-10 seconds) followed by manual exsanguination.

Physical characteristics

Muscle pH of the breast and thigh was measured 30 minutes post-mortem (pH_i) and the ultimate pH (pH_u) 24-hours post-mortem. Muscle pH was measured using a calibrated (standard buffers at pH 4.0 and 7.0) Crison 506 portable pH meter. Eviscerated-carcass weight was recorded and the carcasses stored at 4 ºC for 24 hours. Chilled-carcass weights were recorded, the carcasses portioned and the weights of retail cuts recorded (# Chapter 4 for methodology). The breasts, thighs and drumsticks were then de-boned and the relative contributions of meat, skin and bone recorded (# chapter 4 for methodology). Meat samples were allowed to bloom for 30 minutes after which fresh meat colour (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. From these values the following formulae were used to calculate Hue and Chroma:

$$Hue\ (h_{ab}) = arctangent\left({}^{b*}/_{a*}\right)$$

$$Chroma\ (saturation\ index) = (a*^2 + b*^2)^{1/2}$$

Meat samples were then homogenised, vacuum packed and stored at -20 °C for proximate chemical and fatty acid analysis.

Chemical analysis

Total concentrations of moisture, protein, fat and ash were measured according to standard AOAC methods. The moisture content ($g.\ 100g^{-1}$) of each muscle sample was determined at 100 °C (24h) on a 2.5g sample, according to the AOAC official method 934.01 (AOAC, 2002c). The ash content ($g.100g^{-1}$) was determined on the moisture free sample at 500 °C

(6h) according to the official method 942.05 (AOAC, 2002a). The IMF content ($g.100g^{-1}$) was determined on a 5g sample of muscle, by use of rapid solvent extraction method using chloroform/methanol (1:2 and 2:1 v/v). The filtrate from the latter extraction was then dried and analysed in a Leco Nitrogen/Protein Analyser (Leco Fp-528, Leco Corporation). The crude protein content ($g.100g^{-1}$) was determined according to the Dumas combustion method 992.15 (AOAC, 2002b) from a dry, de-fatted, finely ground sample, encapsulated in a LecoTM foil sheet. The results from this method are given as the nitrogen content (% nitrogen) multiplied by a conversion factor of 6.25 (as meat protein is assumed to contain 16% nitrogen) to determine the total crude protein within each sample (McDonald *et al*., 2002).

Fatty acid methyl esters (FAME) were prepared according to the method of Folch *et al*, (1957). The FAME were analysed with a GC (Varian Model 3300), equipped with flame ionisation detection and two 30 m fused silica megabore DB-225 columns of 0.53 mm internal diameter (J&W Scientific Folsom, CA). Gas flow rates were: hydrogen, 25 ml/min; air, 250 ml/min; and nitrogen, (carrier gas) 5–8 ml/min. Temperature programming was linear at 4 °C/min; initial temperature, 160 °C; final temperature, 220 °C held for 10 min; injector temperature, 240 °C; and detector temperature, 250 °C. The FAME were identified by comparison of the retention times to those of a standard FAME mixture (Nu-Chek-Prep Inc., Elysian Minnesota).

Statistical analysis

Physical and chemical data were analysed using SAS software, version 9.3 of the SAS system for windows (Statistical Analysis System, Version, 9.2, 2006, SAS Institute Inc., CARY, NC, USA). The effect of line on pH_i and pH_u were compared by means of ANOVA by time. Genotypic effects on muscle colour and fatty acid profile were analysed by means of one-way ANOVA GLM procedure. The effect of line on the proximate chemical composition of the breast, thigh and drumstick was analysed by 2-way ANOVA with the main effects being line and portion. Bonferroni *post hoc* tests were used throughout to calculate least square means. For all interpretations a 5% probability level was used to determine significance ($P<0.05$).

5.4 Results

Initial (pH_i) and ultimate pH (pH_u) values of the breast and thigh are shown in Table 5.1. Consistently higher values ($P<0.05$) for both portions for pH_u and pH_i were recorded for the Naked-Neck and Hybrid lines. The breast pH_u of the New-Hampshire lines was intermediary at 5.58 with the Australorp (5.42) and Koekoek (5.42) lines measuring lower (P<0.05) results. Similar results were obtained for thigh pH_u although the Hybrid and New-Hampshire lines did not differ (P>0.05) from each other.

Table 5.1 Means (± std. error) for the initial and ultimate pH of the meat obtained from the three main commercial cuts (breast, thigh, and drumstick) of South African indigenous chickens

	Treatment (Line)				
	Australorp	**New-Hampshire**	**Koekoek**	**Naked-Neck**	**Hybrid**
Breast					
pH_i	5.39^b ± 0.06	5.56^b ± 0.05	5.40^b ± 0.05	6.14^a ± 0.06	5.93^a ± 0.07
pH_u	5.42^c ± 0.04	5.58^b ± 0.04	5.36^c ± 0.03	5.85^a ± 0.04	5.83^a ± 0.02
Thigh					
pH_i	5.72^b ± 0.04	5.76^b ± 0.06	5.70^b ± 0.06	6.36^a ± 0.07	6.19^a ± 0.07
pH_u	5.77^c ± 0.05	5.85^{bc} ± 0.05	5.71^c ± 0.07	6.09^a ± 0.05	6.02^{ab} ± 0.03

[a,b]Means within rows with different superscripts differ significantly (P<0.05)
[1]pH_i Initial pH
[2]pH_u Ultimate pH

Colour results for the three main commercial cuts (breast, thigh and drumstick) are shown in Table 5.2. Differences (P<0.05) were recorded for lightness (L*) of the breast. The Koekoek had the lowest L* score of 56.85. Differences (P<0.05) were also observed for the blue-yellow range (b*) of the breast muscle. The highest b* scores were recorded for the Naked-Neck (11.34) and Hybrid (11.18). No differences (P>0.05) were obtained for the breast red-green range (a*).

Gentotypic differences were observed for all colour parameters (L*, a* and b*) of both the thigh and drumstick muscles (P<0.05). Significantly higher L* values were recorded for the Australorp and Hybrid for both thigh and drumstick. The Naked-Neck line recorded the highest (P<0.05) thigh a* and b* values, 5.78 and 9.39 respectively, whilst the remaining lines recorded similar values for both parameters (P>0.05). The highest (P<0.05) drumstick a* score was recorded for the Naked-Neck at (5.43), whilst the highest b* score was recorded for the Hybrid (9.09). The lowest a* and b* values for all three portions were recorded for the Australorp.

Table 5.2 Means (± std. error) for the colour parameters L*, a*, and b* of the meat obtained from the three main commercial cuts (breast, thigh, and drum) of South African indigenous chickens

	Treatment (Line)				
	Australorp	**New-Hampshire**	**Koekoek**	**Naked-Neck**	**Hybrid**
Breast					
L*	59.28^{ab} ± 0.77	59.16^{ab} ± 0.84	56.85^{b} ± 0.55	60.18^{a} ± 0.63	57.36^{ab} ± 0.64
a*	2.32 ± 0.26	2.95 ± 0.24	2.93 ± 0.31	2.89 ± 0.18	2.24 ± 0.26
b*	8.60^{b} ± 0.47	9.29^{b} ± 0.47	9.08^{b} ± 0.48	11.34^{a} ± 0.32	11.18^{a} ± 0.46
Chroma	9.08^{b} ± 0.35	9.95^{b} ± 0.45	9.17^{b} ± 0.37	11.82^{a} ± 0.26	11.49^{a} ± 0.37
Hue	74.38^{b} ± 1.51	71.83^{b} ± 1.24	72.55^{b} ± 1.15	75.7^{ba} ± 1.02	78.55^{a} ± 1.58
Thigh					
L*	58.46^{a} ± 0.67	56.97^{abc} ± 0.56	54.81^{c} ± 0.64	55.32^{bc} ± 0.49	57.32^{ab} ± 0.64
a*	3.43^{b} ± 0.41	4.55^{ab} ± 0.29	4.19^{b} ± 0.33	5.78^{a} ± 0.32	4.17^{b} ± 0.34
b*	7.32^{b} ± 0.43	8.20^{ab} ± 0.43	7.80^{ab} ± 0.44	9.39^{a} ± 0.28	9.06^{ab} ± 0.55
Chroma	8.30^{c} ± 0.36	9.34^{bc} ± 0.40	8.45^{c} ± 0.30	11.14^{a} ± 0.27	10.25^{ab} ± 0.41
Hue	65.13^{a} ± 2.2	60.08^{ab} ± 1.88	59.98^{ab} ± 1.73	57.47^{b} ± 1.45	63.89^{a} ± 2.36
Drumstick					
L*	58.88^{a} ± 1.11	58.08^{ab} ± 0.77	55.15^{b} ± 1.14	56.73^{ab} ± 0.81	58.10^{ab} ± 0.67
a*	3.18^{b} ± 0.42	3.92^{b} ± 0.30	3.92^{b} ± 0.32	5.43^{a} ± 0.35	3.67^{b} ± 0.22
b*	6.08^{c} ± 0.54	7.09^{bc} ± 0.4	6.39^{bc} ± 0.45	8.07^{ab} ± 0.39	9.09^{a} ± 0.43
Chroma	6.84^{bc} ± 0.43	8.19^{b} ± 0.36	7.54^{bc} ± 0.32	9.82^{a} ± 0.36	9.86^{a} ± 0.35
Hue	62.48^{ab} ± 2.54	60.34^{ab} ± 2.09	57.58^{b} ± 2.05	54.97^{b} ± 1.88	66.76^{a} ± 1.37

^{a,b}Means within the same rows with different superscripts differ significantly (P<0.05)

Genotypic differences were recorded (P<0.05) for chroma and hue for all three portions (Table 3.2). The Naked-Neck and Hybrid lines recorded the highest breast chroma and hue scores. The highest thigh chroma scores were noted for the Naked-Neck and Hybrid, 11.14 and 10.25, respectively. For thigh hue, the Naked-Neck recorded the lowest score (57.47). For drumstick chroma and hue a similar pattern to that of the thigh was noted with the Naked-Neck and Hybrid obtaining the highest chroma scores, 9.82 and 9.86 respectively, although the Naked-Neck recorded the lowest hue score (54.97).

The proximate chemical composition of the three main commercial cuts (breast, thigh and drumstick) is shown in Table 5.3. No genotypic differences (P>0.05) were observed for breast proximate composition, as well as thigh lipid and drumstick ash composition. Differences (P<0.05) were recorded for thigh moisture, protein and ash. The lowest thigh moisture and highest thigh crude protein (P<0.05) was recorded for the Naked-Necks, 72.3% and 18.6%, respectively. The highest (P<0.05) thigh ash values were recorded for the Hybrids (1.1%). Drumstick moisture, lipid and ash content differed (P<0.05) between lines. Similar to the results obtained for thigh proximate analysis, the Naked-Neck obtained the lowest moisture content, (73.6%) for their drumsticks. Of the indigenous lines, the Naked-Neck also had the highest drumstick fat content, 4.4%. The Naked-Neck drumstick muscles had higher (P<0.05) protein and fat when compared to the Hybrid.

Table 5.3 Means (± std. error) for the proximate chemical composition (%) of meat obtained from the three main commercial cuts (breast, thigh and drumstick) of South African indigenous chickens

	Treatment (Line)				
	Australorp	**New-Hampshire**	**Koekoek**	**Naked-Neck**	**Hybrid**
Breast					
Moisture	74.0 ± 0.16	74.1 ± 0.15	73.5 ± 0.15	73.7 ± 0.15	73.8 ± 0.11
Crude Protein	23.5 ± 0.23	23.1 ± 0.19	23.4 ± 0.19	23.1 ± 0.22	23.4 ± 0.26
Lipid	2.1 ± 0.19	2.2 ± 0.14	2.51 ± 0.14	2.4 ± 0.16	2.1 ± 0.14
Ash	1.1 ± 0.04	1.1 ± 0.02	1.1 ± 0.02	1.1 ± 0.02	1.2 ± 0.01
Thigh					
Moisture	74.08^{a} ± 0.38	73.45^{a} ± 0.26	73.7^{a} ± 0.19	72.31^{b} ± 0.28	73.4^{ab} ± 0.22
Crude Protein	17.29^{ab} ± 0.32	16.75^{b} ± 0.43	17.61^{ab} ± 0.25	18.56^{a} ± 0.27	17.6^{ab} ± 0.34
Lipid	7.6 ± 0.51	8.5 ± 0.42	7.2 ± 0.43	8.0 ± 0.4	8.0 ± 0.47
Ash	1.0^{b} ± 0.01	1.0^{b} ± 0.01	1.0^{b} ± 0.02	1.1^{ab} ± 0.03	1.1^{a} ± 0.02
Drumstick					
Moisture	75.7^{ab} ± 0.21	75.2^{ab} ± 0.22	75.0^{b} ± 0.17	73.6^{c} ± 0.17	75.9^{a} ± 0.11
Crude Protein	19.6^{ab} ± 0.21	19.1^{ab} ± 0.13	19.5^{ab} ± 0.2	19.7^{a} ± 0.22	18.9^{b} ± 0.09
Lipid	3.6^{b} ± 0.15	3.8^{b} ± 0.1	3.7^{b} ± 0.16	4.4^{a} ± 0.09	3.5^{b} ± 0.08
Ash	1.1 ± 0.03	1.0 ± 0.02	1.1 ± 0.03	1.1 ± 0.02	1.1 ± 0.01

[a,b]Means within rows with different superscripts differ significantly (P<0.05)

Fatty acid percentage composition of the meat obtained from the thigh muscle is shown in Table 5.4. No genotypic differences (P>0.05) were observed for the proportion of palmitic acid (C16:0) (~21%) and stearic acid (C18:0) (~7%).

Genotypic differences (P<0.05) were noted for myristoleic acid (C14:1) with the highest proportion being observed for the Australorp and Hybrid (0.09%). Genotypic differences (P<0.05) were also observed for nervonic acid (C24:1n9) with the highest proportion noted for the Australorp (0.28%). No genotypic differences (P>0.05) were recorded for the proportion of thigh pamitoleic acid (C16:1n7) and oleic acid (C18:1n9) measured in the thigh muscle.

Differences (P<0.05) were recorded for linoleic acid (C18:2n6c), and homo-g-linolenic acid (C20:3n6) with the Australorp obtaining the highest proportion for both, 23.37% and 0.23% respectively.

Table 5.4 Means (± std. error) for the fatty acid composition (%) of meat obtained from the thigh of South African indigenous chickens reared to an average weight of 2kg on a commercial broiler diet

	Treatment (Line)				
	Australorp	**New-Hampshire**	**KoeKoek**	**Naked-Neck**	**Hybrid**
SFA					
C14:0	0.43[a] ± 0.031	0.39[ab] ± 0.034	0.33[ab] ± 0.035	0.28[b] ± 0.034	0.300[ab] ± 0.037
C15:0	0.09 ± 0.007	0.08 ± 0.007	0.08 ± 0.007	0.06 ± 0.007	0.06 ± 0.008
C16:0	23.64 ± 1.481	20.86 ± 1.594	21.47 ± 1.671	17.88 ± 1.59	19.77 ± 1.754
C18:0	8.95 ± 0.588	8.18 ± 0.633	7.46 ± 0.664	6.65 ± 0.631	6.48 ± 0.696
C20:0	0.07[a] ± 0.005	0.06[ab] ± 0.005	0.06[ab] ± 0.005	0.05[b] ± 0.005	0.05[ab] ± 0.006
C21:0	0.30 ± 0.019	0.27 ± 0.021	0.24 ± 0.022	0.22 ± 0.021	0.23 ± 0.023
C22:0	0.17 ± 0.019	0.11 ± 0.02	0.14 ± 0.021	0.16 ± 0.02	0.13 ± 0.022
MUFA					
C14:1	0.09[a] ± 0.01	0.07[ab] ± 0.01	0.08[ab] ± 0.011	0.05[b] ± 0.01	0.09[ab] ± 0.011
C16:1n7	4.09 ± 0.363	2.79 ± 0.391	4.25 ± 0.41	2.90 ± 0.39	4.47 ± 0.43
C18:1n9c	31.82 ± 4.027	41.45 ± 4.333	38.20 ± 4.544	49.50 ± 4.322	48.92 ± 4.768
C18:1n9t	0.18 ± 0.061	0.14 ± 0.065	0.25 ± 0.068	0.11 ± 0.065	0.31 ± 0.072
C20:1n9	1.07[a] ± 0.074	0.81[ab] ± 0.074	0.96[ab] ± 0.074	0.75[b] ± 0.074	077[ab] ± 0.074
C22:1n9	0.04 ± 0.005	0.04 ± 0.005	0.04 ± 0.006	0.03 ± 0.005	0.04 ± 0.006
C24:1n9	0.28[a] ± 0.021	0.23[ab] ± 0.022	0.24[ab] ± 0.023	0.18[b] ± 0.022	0.19[ab] ± 0.025
PUFA					
C18:2n6c	23.37[a] ± 1.334	19.42[abc] ± 1.435	21.42[ab] ± 1.505	16.84[bc] ± 1.431	14.47[c] ± 1.579
C18:2n6t	1.56 ± 0.149	1.73 ± 0.161	1.53 ± 0.168	1.38 ± 0.160	1.06 ± 0.177
C18:3n3	0.34 ± 0.030	0.30 ± 0.030	0.32 ± 0.030	0.29 ± 0.030	0.29 ± 0.030
C18:3n6	0.08[a] ± 0.006	0.05[ab] ± 0.006	0.06[ab] ± 0.006	0.04[b] ± 0.006	0.05[ab] ± 0.006
C20:2	0.05 ± 0.006	0.04 ± 0.006	0.05 ± 0.006	0.04 ± 0.006	0.05 ± 0.007
C20:3n6	0.23[a] ± 0.014	0.16[b] ± 0.015	0.17[b] ± 0.016	0.13[b] ± 0.015	0.12[b] ± 0.016
C20:3n3	0.46[a] ± 0.039	0.38[ab] ± 0.042	0.40[ab] ± 0.044	0.34[ab] ± 0.042	0.45[b] ± 0.046
C20:4n6	2.31 ± 0.185	2.01 ± 0.199	1.83 ± 0.209	1.69 ± 0.199	1.50 ± 0.219
C20:5n3	0.04 ± 0.004	0.03 ± 0.004	0.02 ± 0.004	0.02 ± 0.004	0.03 ± 0.005
C22:5n3	0.06 ± 0.006	0.05 ± 0.006	0.06 ± 0.006	0.05 ± 0.006	0.06 ± 0.007
C22:6n3	0.32 ± 0.029	0.30 ± 0.031	0.26 ± 0.032	0.29 ± 0.031	0.21 ± 0.034
Total					
SFA	34.08[a] ± 2.177	29.33[ab] ± 2.177	29.04[ab] ± 2.177	24.05[b] ± 2.177	28.61[ab] ± 2.177
MUFA	36.82[b] ± 3.660	48.47[ab] ± 3.660	43.16[ab] ± 3.660	54.00[a] ± 3.660	50.00[ab] ± 3.660
PUFA	27.62[a] ± 1.743	20.68[abc] ± 1.743	26.29[ab] ± 1.743	19.80[bc] ± 1.743	18.00[c] ± 1.743
TUFA	64.87 ± 2.15	68.42 ± 2.314	68.64 ± 2.427	73.40 ± 2.308	71.79 ± 2.546
P:S	0.81[ab] ± 0.037	0.71[ab] ± 0.037	0.82[a] ± 0.037	0.83[a] ± 0.037	0.66[b] ± 0.037
n-6	26.32[a] ± 1.648	19.68[abc] ± 1.648	25.15[ab] ± 1.648	18.86[bc] ± 1.648	17.59[c] ± 1.648
n-3	1.24 ± 0.145	0.95 ± 0.145	1.08 ± 0.145	0.89 ± 0.145	1.35 ± 0.145
n-6:n-3	21.38[a] ± 0.894	20.84[a] ± 0.894	21.30[a] ± 0.894	19.81[a] ± 0.894	15.23[b] ± 0.894

[a,b]Means in same rows with different superscripts differ significantly (P<0.05)

Differences (P<0.05) were observed for total SFA and MUFA. The lowest SFA and highest MUFA content was measured for the Naked-Neck chickens, 24.05% and 54.00% respectively. Total PUFA differed (P<0.05), with the lowest proportion being observed for the Hybrid (18.00%) and the highest for the Australorp (27.62%). Differences (P>0.05) were recorded for the ratio of polyunsaturated fatty acids to saturated fatty acids (P:S), total omega-6 (n-6), and the ratio of omega-6 to omega-3 fatty acids (n-6:n-3). A higher ratio of polyunsaturated to saturated (P:S) fatty acids was observed for the indigenous lines (0.71-0.83) when compared to the Hybrid (0.66). A similar result was noted for the ratio of omega-6 and omega-3 fatty acids, a higher ratio of n-6:n-3 was observed for the indigenous lines (19.81-21.38) when compared with the Hybrid (15.23).

5.5 Discussion

The lower pH_u recorded for the Australorp, New-Hampshire and Koekoek lines could be associated with PSE-like conditions resulting in a more rapid decline in tissue pH. Barbut (1997) showed a strong correlation between a lower pH_u and PSE as well as a strong correlation between pH_u and colour. In the current study the higher tissue pH_u results documented for the Naked-Neck and Hybrid corresponded with higher b* and chroma scores for the breast muscle and higher a*, b* and chroma scores for the thigh muscle. Lines with a higher tissue pH_u tend to have a darker colour (Barbut, 1997) . The muscles of the Naked-Neck and Hybrid which had a higher pH_u were significantly redder (a*) and darker (chroma) than those of the remaining lines. Ultimate pH (pH_u) and muscle colour have been shown to be highly correlated with higher muscle pH_u being associated with darker meat (Wattanachant *et al*., 2004). The tendency for indigenous chicken meat to be darker or redder has been shown to be a result of slower growth, higher physical activity and genetics. These differences are a result of the structure and function of avian muscle fibre types. The muscles of indigenous birds are higher in red muscle fibre (myoglobin and iron rich, and adapted to aerobic metabolism) (Dransfield & Sosnicki, 1999).

The lines reared for the purposes of this trial were reared in an environmentally controlled facility in raised pens and were fed the same diet. It is thus assumed that any differences that were observed between lines, for chemical composition and fatty acid profile, are a result of genetic differences. Faster growing chickens will tend to have a higher proportion of larger white muscle fibres than slower growing chickens which have more red muscle fibres that are smaller in diameter (Dransfield & Sosnicki, 1999). These differences result in differences in their chemical composition. The results obtained for the indigenous lines during the course of this trial compared well with those obtained by Wattanachant (2008), who concluded that genetics, age and rearing system had an effect on muscle chemical composition. It was found that with increasing age, moisture content decreased whilst protein and fat increased. Berri (2001) also showed that with increasing age muscle protein content increased while moisture decreased. In comparison to the results obtained by Wattanachant (2008), the indigenous lines reared in the current study had similar moisture and protein content, and higher fat content. Coetzee & Hoffman (2002) fed varying amounts of saturated and unsaturated fats to broilers and found no differences in the carcass proximate composition as a result of dietary fatty acid inclusion. The broilers from the trial of Coetzee & Hoffman (2002) had lower moisture (~66%), protein (~17%) and ash (~0.90%), and higher fat (~17%) than that of the South African indigenous lines reared in this trial.

Although the effect of line (i.e. heritability) on the fatty acid profile of chicken meat is low compared to the effect of feeding behavior and diet, it is believed that different growth intensity as a result of line might still affect the fatty acid profile (Jaturasitha *et al*., 2008). 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. 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). In the assessment of broiler carcass composition by Coetzee & Hoffman, (2002), broiler fatty acid composition yielded similar SFA (~29%), MUFA (45%) and PUFA (~23%) proportions in comparison to the lines reared in the current study. All lines reared in this trial obtained a lower ratio of n-6/n-3 fatty acids when compared to the broilers assessed by Coetzee & Hoffman (2002).

5.6 Conclusion

The fast-growing boiler stains prevalent in commercial broiler production are a testament to the genetic improvement and progress made in poultry management and nutrition. This trend has resulted in appearance defects (morphological disorders) and meat quality problems associated with texture, colour, and water holding capacity (Dransfield & Sosnicki, 1999). As a result the use of slower-growing lines raised in alternative production systems, such as free-range, is growing in popularity. The increasing popularity of the use of alternative lines and production systems is directly linked to the effect of a slower growth rate and increased physical activity on meat quality as well as animal welfare (Cheng *et al*., 2008).

Due to the slower growth rate and increased costs of production associated with a comparatively poor FCR (# Chapter 3) the selling price of indigenous chicken products is 2-3 times higher (Wattanachant, 2004). Although, in countries where free-range indigenous poultry production is growing in popularity, consumers are willing to spend more for products they perceive as healthier and humanely farmed. For example, in Taiwan indigenous chicken consumption accounts for half of all chicken consumed per capita (Cheng *et al*., 2008).

The development of niche markets is essential to promoting the production and consumption of indigenous poultry meat. Consumers have become accustomed to the 'quality' associated with commercially produced lines and are thus not used to the differences in quality associated with indigenous chicken meat. The darker colour, firmer texture and different flavour all contribute to differences that will be reflected in the consumer acceptance of the products. In addition to the development of indigenous chicken production for the consumer, the need to identify a means of eradicating the negative effects of selection for fast growth on meat quality is essential. The identification of slower-growing lines that can be produced in a cost effective manner is one of the first steps to preventing production based meat defects.

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Chapter 6

General Conclusion

The ultimate purpose of this study was to quantify the production performance parameters, and carcass and meat characteristics of chicken lines that are indigenous to South Africa. The four lines that featured in the study gave a good representation of which 'backyard' chicken lines occur commonly in South African rural settings. The Koekoek and Naked-Neck being the two traditionally backyard lines of South Africa, and the Australorp and New-Hampshire representing lines that were developed elsewhere that thrive in backyard conditions, although they were originally developed as layer lines. The Cobb 500 and Koekoek hybrid was included for comparison and because the use of hybrids in free-range/organic production is increasing in popularity as is done in the French Label Rouge system.

The results from the trial highlight the vast difference in production performance when comparing indigenous lines to broiler strains or their hybrids under commercial intensive production conditions. On growth performance alone, the potential of these indigenous lines as an intensive produced agricultural product is doubtful. The feed conversion ratio was almost twice that what one could expect from a commercial broiler. Without the development of niche markets, the intensive production of indigenous birds would be far too expensive and drawn out to warrant commercial production under intensive production systems.

This is not to say the potential of developing niche markets is out of the question. Despite their slower growth rate, indigenous chickens have the advantage in that they can be raised with minimal input and low production costs. They can also be raised outdoors/free range, a concept that is growing in popularity when regarding the ethical demands of some modern consumers as pertaining to the welfare of the animals that produce the meat they consume. From the results of this study it has become evident that further research needs to be done in order to formulate specific diets that suit the nutritional demands of the slower-growing lines. By doing so the cost of production of the indigenous lines could be optimized.

With the growing popularity of free-range poultry production a need to identify lines suited to the methods employed by these systems has been highlighted. The Hybrid grown in this study would have been the most suited to commercial free-range production. Whilst performing significantly better than the indigenous chickens, the Hybrid still maintains the characteristics associated with indigenous poultry. Its growth performance was superior to that of the indigenous lines, roughly mid-way between the growth potential of the indigenous lines and commercial broilers.