THE EFFECT OF DIFFERENT SLAUGHTER AGE REGIMES ON THE PRIMARY AND SECONDARY PRODUCTION PARAMETERS OF OSTRICHES (STRUTHIO CAMELUS DOMESTICUS) AND THE ECONOMIC CONSEQUENCES OF DIFFERENT SLAUGHTER AGES.

by

CLOVIS SOLOMON BHIYA

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School of Natural Resource Management
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Promoter: Mr. J.W. Jordaan
Co-promoter: Prof. T.S. Brand
DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work. It is being submitted for the Degree, Magister Technologiae: Agriculture at the Nelson Mandela Metropolitan University, George Campus, and Saasveld. It has not been submitted before for any degree or examination at any other University.

Signature:  
Date: 22 September 2006
ABSTRACT

The South African ostrich industry is presently characterised by a drastic decline in the slaughter price of slaughter birds, due to the drop in the price of meat as well as leather. As a result, the economic viability of ostrich farming is severely hampered by these developments, and many generally accepted industry practices have to be reviewed. Among the practices under review is the possibility of slaughtering ostriches at an earlier age than the traditional slaughter age of 12 - 14 months, in order to minimise feed costs and the incidence of damage to the skin. However, little information is available on the effect of the slaughter age on the yield and quality of the economically important end-products. The effect of slaughter age on production and the economic viability of a commercially intensive ostrich production system was consequently evaluated in a completely randomised experimental design involving two batches (n= 81 and n= 94) of ostriches. The experiments took place at Kromme Rhee experimental farm of the Elsenburg Research Centre near Stellenbosch. The birds were subject to experimental treatment at the age of 4 months (n= 81, from May 2004 to March 2005) and 6 months (n= 94, from August 2004 to August 2005) respectively. The ostriches were randomly divided into 10 groups of between 16 and 20 birds per group. Standard production practices, as applied in an intensive ostrich production unit, were implemented. Clean drinking water and self-mixed grower diet (min 15% crude protein, 0.68% lysine and 11.4 MJ ME per kg feed) and finisher diet (min 14% crude protein, 0.55% lysine and 9.8 MJ ME per kg feed) were provided ad libitum to the birds. Birds were slaughtered at the ages of 8.5, 10.5, 12.5, 14.5, and 16.5 months respectively.

Data on feed intake and yields of cold carcass, crust skin size, skin grade and total feathers was recorded for birds slaughtered at the respective ages. Data was analysed according to the analysis of variances. Values for meat yield, skin size yield and feed intake were predicted by regression analysis based on experimental values. Industry figures and norms were used as proxy for other production inputs and costs. A gross margin type analysis was performed to evaluate the effect of different slaughter ages on the profitability of each production system.

There was a positive correlation between age and feed intake ($r^2 = 0.40$), slaughter weight ($r^2 = 0.97$), cold carcass yield ($r^2 = 0.48$), skin surface area ($r^2 = 0.39$), skin grade ($r^2 = 0.19$) and total yield of feathers ($r^2 = 0.29$). The dry skin grade showed deterioration as
slaughter age was prolonged. Highly significant differences (P< 0.01) in slaughter weight, cold carcass yield, skin surface area, dry skin grade and total feathers were detected at the different slaughter ages. There were no significant differences (P> 0.05) with respect to gender for slaughter weight, skin surface area and dry skin grade within the different age groups. Males had significantly higher (P< 0.05) cold carcass yield and total feather yield than their female counterparts. From this study it can be concluded that an increase in slaughter age significantly increases feed intake, slaughter weight, cold carcass yield, and skin surface area. It is also clear that an increase in slaughter age can be detrimental to dry skin grade.

The relative income contribution of the three main products (skin: meat: feathers) occurred in a ratio of 47:53:0, 52:47:1, 47:50:3, 44:51:5, 39:56:5 at the respective slaughter ages. Total income revealed an increase of 26 % from 8.5 to 10.5 months slaughtering, an increase of 4% between 10.5 and 12.5 months, and an increase of 11% between 12.5 and 14.5 months. The income dropped by 0.3 % between 14.5 and 16.5 months slaughtering. Total costs increased with slaughter age, particularly feed costs which showed an increase (at a decreasing rate) between the different slaughter ages. The margin above specified cost per bird was the highest for birds slaughtered at the age of 10.5 months. The margin above cost showed a steady decline as birds were slaughtered at higher ages. Slaughtering at 16.5 months revealed a negative margin. To compare the effect of differences in time span on different slaughter age regimes, margin above costs for each system over 5 years were discounted to a present value. In this study, with current feed costs and income from end products, slaughtering at 10.5 months revealed the highest present value for the margin above cost. Furthermore, slaughtering at 16.5 months revealed a negative present value on the margin above cost after 5 years.

Financial viability calculations are relevant and valid for data obtained in this case study. Financial viability is however case-specific and may vary between producers, depending on their individual management practices, production systems and cost structures. Results from this study may be of significant value to managerial decision-making in the ostrich industry.
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Glory and honour is due to the Heavenly Father who made this study possible through the provision of the following persons and institutions.

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God Bless You All…

God Bless You All…

God Bless You All…

God Bless You All…
NOTE

The language and style used in this thesis are in accordance with the requirements of the South African Journal of Animal Science. This thesis represents a compilation of manuscripts where each chapter is an individual entity and some repetitions between the chapters has therefore, been unavoidable. It should be noted that each chapter has its own reference list instead of one comprehensive list appearing at the end of the thesis.

Parts of the results from this study have been presented at the following Congresses/Symposia and Journals:

**Posters**


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CHAPTER 1

GENERAL INTRODUCTION

1.1 INTRODUCTION

The ostrich feather trade collapsed after the Second World War, but ostrich skin and meat were still thought to have commercial potential, so a commercial ostrich abattoir was established in 1965 in Oudtshoorn, the headquarters of the ostrich industry. This was followed in 1970 by a tannery (Lambrechts, 2004). Although the South African Ostrich Industry currently provides 60% of all ostrich products in the world (South African Ostrich Business Chamber, 2002), it is hampered by high feeding costs which are estimated at 70 – 80% of total production costs (Van Zyl, 2001).

While it is often thought that the qualities of the ostrich end-products are determined at the abattoir and tannery, it remains the responsibility of the producer to deliver a slaughter bird of acceptable weight and optimal skin size and quality. Only then will processors be able to effectively add value to and market these products.

Decision-making in any commercial enterprise is aimed at ensuring maximum profit for the venture. However, the decisions made depend mainly on market requirements for the end-products and input costs of the enterprise. In the South African Ostrich Industry, decision-making is centered on:

1. Slaughter age,
2. Feed costs,
3. Yield and quality of the end-products.

It is anticipated that this study will demonstrate that an overall greater efficiency in the ostrich production system with regard to these aspects will bring about an increase in the profitability of the industry.
1.2 BACKGROUND AND MOTIVATION OF THE STUDY

Ostriches were traditionally slaughtered at 14 months of age, apparently because this was the time when optimal skin size was supposedly attained (Jarvis, 1998a). This slaughter age occurred because feathers from slaughter birds were partially harvested at seven to eight months of age to ensure a mature feather crop with optimal follicle development at 14 months of age (Angel, 1996). However, rising feed costs and an increased emphasis on damage to skin favours slaughter at a younger age (Cloete, Van Schalkwyk & Pfister, 1998).

It is widely speculated that the high prevalence of scratch and kick marks on ostrich skins are related to the onset of puberty and associated behavioural changes at the age of 14 months (Meyer, 2003). From the end-product point of view, the hide quality is allegedly affected most if the bird is slaughtered before 14 months of age (Boast, 1997). There has been considerable debate worldwide as to the effect of slaughter age on the quality of ostrich end-products, particularly the skin, and thus the profitability of the industry (Jarvis, 1993; 1996a; 1996b; 1996c; 1997; 1998b; Boast, 1997; Angel, Trevino, Mantzel, Baltmanis, Blue-MacLendon, & Pollock, 1997; Henderson, 1996; Van Zyl, 1996). In the ostrich industry, the income that is obtained from the hide is of extreme importance to the economics of commercial ostrich production (Angel et al., 1997; Cloete, Van Schalkwyk, Hoffman & Meyer, 2004).

Quality control is stringent and the majority of ostrich skins currently cured receive low grading due to visible skin defects (Meyer, 2003). Managing skin damage to stabilize income from slaughter birds can therefore be considered a major objective of the ostrich industry. Despite the economic importance of ostrich leather, little research to date has focused on aspects like leather quality and skin damage (Jarvis, 1996d; Meyer, 2003).

Angel (1996) and Mellett, Fisher & Böhme (1996) were probably the first authors to emphasize the need to protect skins from damage, particularly from on-farm scarring. Although aspects of skin quality like slaughter age and follicle development have been investigated, limited research is available on the relation between slaughter age and economics (Cloete et al., 2004). Any research regarding this topic will therefore be valuable to the industry. Due to the marked difference in price between a defect-free skin and a skin downgraded because of damages incurred over the traditional slaughter age of 14 months,
even a small improvement in skin quality will have obvious financial implications for the industry.

A preference for slaughtering at the earlier age of about 10 – 12 months developed around the year 2000 (Meyer, 2003). This was partly motivated by advances in ostrich nutrition, which enabled ostriches to reach slaughter weight at an earlier age, and partly by the financial implications of maintaining slaughter birds up to 14 months. During 2002, there was a return to slaughtering birds at 14 months of age, which was advocated mainly for the attainment of acceptable follicle development, which was apparently not obtained with younger slaughter birds (Meyer, 2003).

In an attempt to address the problem of nutritional management systems and the relation of slaughter age to the yield of ostrich end-products, this study proposes to clarify in broad terms some of the prevailing uncertainties regarding the relationship between slaughter age and the economics of an intensive ostrich production system.

1.3 PROBLEM STATEMENT

The study therefore, will investigate the effect of different slaughter ages of ostriches (*Struthio camelus var domesticus*) on primary and secondary production parameters, and the economic viability of commercial ostrich production under different slaughter age regimes.

1.4 AIM OF THE STUDY

Several primary production parameters and management practices in a commercial farming environment were evaluated with regard to slaughter age and the economics of the ostrich enterprise. The aim was to determine the effect that slaughtering at different ages (8.5, 10.5, 12.5, 14.5, and 16.5 months) had on the grading of the skin, and the yield of skin surface area, meat and feathers.

Key aspects that were addressed are:

1. Feed intake during the production stages up to the respective slaughter ages.
2. Slaughter weight of birds at 8.5, 10.5, 12.5, 14.5 and 16.5 months of age respectively.
3. The extent to which the yield of meat (cold carcass mass), skin (skin surface area) and feathers (quantity of feathers) differed between birds slaughtered at 8.5, 10.5, 12.5, 14.5, and 16.5 months respectively.

4. The extent to which the quality of skin (dry skin grade) differed between birds slaughtered at 8.5, 10.5, 12.5, 14.5, and 16.5 months respectively.

5. The quantity of production inputs and associated costs at different slaughter ages (directly allocatable costs).

6. The effect of the above-mentioned slaughter ages on the profitability of an intensive ostrich production system.

1.5 EXPERIMENTAL DESIGN

The research was conducted from May 2004 to August 2005 at the Kromme Rhee Experimental Farm of the Elsenburg Research Centre in the Western Cape Province near Stellenbosch (Cape wine-land area), South Africa. The experimental site is situated at longitude 18°50’E and latitude 33°51’S at an altitude of 177m above sea level (see Appendix A). The climate at Elsenburg is typically Mediterranean, with a mean annual rainfall of 622.7 mm (30 year average) of which 84 % occurs between April and October (Labuschangne, 2005).

The experimental birds used in this study were African Black ostriches (*Struthio camelus var domesticus*) (Swart, 1988), obtained from ostrich producers in the Western Cape. Standard management practices for ostriches as applied by the Ostrich Research Unit of Elsenburg for rearing and raising chicks were implemented. Only grower (4 – 6 months of age) and finisher (6 – 16 months of age) diets with specified protein and energy dietary composition as documented in Brand *et al.* (2002) were used in this study. Slaughtering took place at a commercial abattoir in Malmesbury, accredited by the European Union (EU), Hazard Analysis and Critical Control Point (HACCP), and British Retail Consortium (BRC). It is located about 50 kilometres from the experimental farm. Skin processing was performed at Swartland Tannery in Wellington. The research focused only on meat yield (carcass mass), skin (skin surface area and skin grading) and feathers (quantity per bird) of the ostriches slaughtered at 8.5, 10.5, 12.5, 14.5, and 16.5 months of age respectively.
The language and style used in this thesis are in accordance with the requirements of the South African Journal of Animal Science. The thesis represents a compilation of manuscripts. Each chapter is an individual entity, consisting of an abstract, introduction, materials and methods, results and discussion, conclusion, and references. Some repetition between the chapters has been unavoidable. There are two central chapters, namely:

1. The effect of the slaughter age on the production of ostriches and yield of end products.
2. The impact of slaughter age on the profitability of an intensive slaughter ostrich production system.

With the analysis of various management aspects, together with data collected in this study, it is hoped that a contribution will be made to available scientific information in order to improve the profitability of the ostrich industry. The background of the ostrich industry and the different aspects of the ostrich production system are thoroughly discussed in the next chapter, under the literature review.

1.6 REFERENCES


CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

There is relatively little accumulated knowledge about any aspect of the ostrich as a production animal compared to other traditional farmed species, especially with regard to the economics of slaughter age in relation to the end products (Pollok, Miller, Hale, Angel, Blue-McLendon, Baltmanis & Keeton, 1997). This study aims to supply reliable scientific information on ostrich nutrition, the economic importance of nutrition in commercial ostrich production, as well as the importance of the South African Ostrich Industry per se. This chapter will review significant aspects pertaining to the effect of slaughter age on:

1. The primary production parameters (feed intake, feed conversion and average daily gain),
2. The end-products (skin, meat and feathers), and
3. The economics of ostrich production.

In order to produce an ostrich product that can compete with other well-known products in established markets, it is important to know and understand the yield and quality characteristics of that product at different slaughter ages, in order to utilize it to its full potential.

2.2 BACKGROUND

For centuries the demand for feathers was met by killing wild ostriches with no attempt to develop a non-lethal method of harvesting (Smit, 1963). Around the early 1860s in the Karoo and Eastern Cape Province of South Africa, ostriches were taken into captivity for the production of feathers for fashion items (Douglass, 1881; Smit, 1963; Jensen, Johnson & Weiner, 1992). Douglass (1881) states that he was undisputedly the first person to make ostrich farming his sole occupation. He went on to design and patent the first ostrich incubator in 1869, which he named the ‘Eclipse’. Towards 1913 ostrich feathers were as economically important as gold, diamonds and wool, being one of South Africa’s most
important export products. Shortly after this period, the entire feather market, and thus the ostrich industry, collapsed after the outbreak of the First World War (Joubert, 2003).

A resurgence of interest in ostriches arose during the 1960s, and, as a consequence, was transformed into an intensive industry (Van Zyl, 2001). At this stage the emphasis shifted away from feathers towards the production of leather as an all-important export product (Van Zyl, 1996b). Ostrich meat became a competitive marketing product when the first ostrich abattoir in South Africa was opened in 1967 in Oudtshoorn (Marks, Stadelman, Linton, Schmieder & Adams, 1998). The export of ostrich meat was only started in 1977, when the first batch of meat was exported to Switzerland (Lambrechts & Swart, 1998).

The main problem with the ostrich industry is that the ostrich has been treated as a single-commodity animal (Huchzermeyer, 1998). Firstly it was kept solely for its feathers. Changes in the fashion industry led to the discovery of ostrich leather and leather became the all-important commodity (Joubert, 2003). Feathers were still traded, but only reflected a small percentage of the overall revenue. Then a demand for ostrich meat arose and it was also marketed, although not very enthusiastically (Huchzermeyer, 1998). A change in fashion, coupled with an overproduction of mainly poor quality leather obtained from younger ostriches, deflated the international leather market in 1998 (Cloete, Van Schalkwyk, & Pfister, 1998; Van Zyl, 2001), resulting in yet another challenge facing ostrich commodities.

The primary product of the ostrich industry, however, remained leather, worth an estimated R300 million per annum to the industry (Van Zyl, 2001). Cloete, Van Schalkwyk & Brand (1998a) estimated the contribution of ostrich leather to total income at approximately 70%. The dominance of leather in the profitability of the ostrich industry declined with ostrich meat becoming more popular in European countries after the Bovine Spongiform Encephalopathy (BSE) crisis and rapid decline of beef sales in 1996 (Adams & Revell, 2003) and again in 2000 (Van Zyl, 2001). Leather, however, still contributes more than 50 % of the total income of ostrich producers, depending on the quality of the skin (Cloete, Van Schalkwyk, Hoffman & Meyer, 2004).

Since 2000, ostrich meat has become an increasingly important product of ostrich farming, contributing greatly to the stabilization of the industry (Van Zyl, 2001). The
outbreak of BSE and Foot and Mouth diseases in large parts of Europe during that year, led to an increased demand for an alternative safe red meat source other than beef (Van Zyl, 2001). Ostrich meat is an ideal substitute for other red meat types, due to its colour, aroma, favourable fatty acid profile and low intra-muscular fat content (Lambrechts & Swart, 1998; Sales, 1994). Ostrich meat is also lower in calories than other red meat types and competitive with regard to taste, texture and tenderness (Joubert, 2003). As far as meat production is concerned, only the two legs, the neck and the gizzard are of economic importance (Van Zyl, 2001).

A live ostrich of 90 kg provides approximately 25 kg of meat, only half of which can be used for export (Van Zyl, 2001). The ostrich is therefore not a very cost-effective meat source, because the feed cost required for producing a kilogram of cold carcass increases steadily with increasing age (Jarvis, 2001). The role of ostrich meat in the market place is, however, significant and its contribution to the revenue of the ostrich enterprise cannot be ignored. The production of ostrich meat in South Africa is still perceived to be uneconomical, due to the high feed conversion ratio of 12.8 for an ostrich between the weight of 60 and 110 kg, and the low meat yield of ca 28 % (Van Zyl, 2001). These primary production parameters are therefore the basis for determining the requirements of the bird at different ages, and thus, the profitability of the ostrich industry.

2.3 PRIMARY PRODUCTION PARAMETERS

For better understanding of the nutrition of ostriches, it is important to understand the natural diet and the physical and functional properties of its gastro-intestinal tract (Cilliers & Angel, 1999). Like pigs and poultry, ostriches are monogastric animals. Ostriches are herbivores (plant eaters) and their digestive system has adjusted to cope with large amounts of low-quality, fibre-rich plant material (roughage) (Angel, 1996). Fibre-rich material is largely digested and absorbed in the lower digestive tract of monogastric animals. The lower digestive tract of an ostrich is much larger than that of poultry or pigs in relation to the total digestive tract (Brand, Nel, Brand & Van Schalkwyk, 2002a). This larger lower digestive tract is directly associated with its ability to digest fibrous materials. The type of diet given to ostriches also has an effect on the relative size of the lower digestive tract (Brand et al., 2002a). The age of an ostrich also has an influence on the digestion of fibre. In research by Angel (1996) it was found that three-week old ostriches digest 6.5 % of natural-detergent
fibre (NDF) in their diet, while mature ostriches (30 months old) digest 61.5 %. Cilliers & Angel (1999), and Brand, Brand and Brown (2002b), found that nutritional information extrapolated from the poultry industry has been used widely, but often proved unsatisfactory for ostriches and has resulted in several nutrition-related problems, as well as high feed costs.

Feed conversion ratio and average daily gain are the primary measures of growth performances in ostrich production (Table 2.1). The composition of ostrich diets varies considerably. Current information provides general guidelines for the protein, amino acid and energy content of diets for growing ostriches in relation to the relative nutrient requirements during different growth and production stages (Brand et al., 2002a). In a study by Salih, Brand, Van Schalkwyk, Blood, Pfister, Brand & Akbay (1998), where ostriches were fed starter, grower and finisher diets with three energy levels, better growth rates and feed conversion ratios were recorded for birds on high energy levels during the starter phase. No significant differences were, however, observed in the feed conversion ratio between the high, medium and low energy diets during the grower and finisher phases of that study. This result was unexpected as high energy diets normally lead to better feed conversion ratios and higher growth rates (Brand et al., 2002a). The relative differences in the energy contents of the diets consumed probably played a major role.

2.3.1 Dietary requirements and feed intake at different ages

Correct diet formulation, the use of balanced least-cost diets and the lowest possible purchase price of raw materials and additives, are crucial for achieving possible feed cost savings (Brand & Jordaan, 2004). The palatability of feed is fundamental in order to stimulate feed ingestion by the birds (Aganga, Aganga & Omphile, 2003). Common feed ingredients that are used on ostrich diets are: maize and small grains as a source of concentrated energy, lucerne (alfalfa) and wheat bran as a source of protein and fibre. Fishmeal, soybean oilcake and canola oilcake meal are sources of crude protein and lipids, especially the essential fatty acids (linoleic and linolenic acids). Vitamin/ mineral premixes are also included in the rations as a premix. Limestone is a source of calcium while mono-calcium and di-calcium phosphate supplies calcium and phosphorus. Salt composed of sodium and chlorine is required to establish electrolyte balance in the birds (Aganga et al., 2003).
Fresh clean water must be readily available for the birds on an *ad libitum* basis. The ostrich has a lower evaporative loss and a higher faecal and urinary loss than mammals of similar body weight. As a result, the ratio of water intake to dry matter intake is relatively constant at about 2.3 ml water for every gram of dry feed intake (Degen, Kam, Rosenstrauch & Plavnik, 1991).

According to Brand, Gous, Brand, Aucamp, Kruger & Nel (2003), young birds consume *ca* 14% of their total feed from hatching up to slaughtering during the pre-starter (hatching up to 5 kg live weight) and starter (5 kg up to 30 kg) phases. Feed consumed by the young bird amounts to *ca* 70 kg i.e. *ca* 8 kg during the pre-starter and *ca* 62 kg during the starter phase (Brand, 2001). During the grower phase (*ca* 30 – 60 kg live weight) and finisher phase (*ca* 60 – 95 kg live weight), approximately 430 kg feed (150 during the grower phase and 280 kg during the finisher phase) is consumed per bird. This represents *ca* 86% of the total feed normally consumed by birds from hatching up to slaughtering (total of *ca* 500 kg per bird) (Brand, 2001). The grower and finisher phases are of economic significance to the ostrich producer (Brand *et al.*, 2003). Table 2.1 illustrates the practical feed requirements for producing ostriches under intensive feedlot conditions.

### Table 2.1 Primary production parameters for slaughter birds based on feed pellets.

<table>
<thead>
<tr>
<th>Period/Interval</th>
<th>Age Interval</th>
<th>Mass (kg)</th>
<th>DMI (g/bird/day)</th>
<th>ADG (g/bird/day)</th>
<th>FCR (kg feed/kg gain)</th>
<th>Annual Feed Intake (kg/bird)</th>
<th>Cumulative Feed Intake (kg/bird)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-starter</td>
<td>0 - 2</td>
<td>1 - 10</td>
<td>275</td>
<td>150</td>
<td>1.80</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Starter</td>
<td>2 - 4.5</td>
<td>10 - 40</td>
<td>1100</td>
<td>400</td>
<td>2.75</td>
<td>84</td>
<td>100</td>
</tr>
<tr>
<td>Grower</td>
<td>4.5 - 6.5</td>
<td>40 - 60</td>
<td>1650</td>
<td>330</td>
<td>5.00</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Finisher</td>
<td>6.5 - 10.5</td>
<td>60 - 90</td>
<td>2500</td>
<td>240</td>
<td>10.00</td>
<td>300</td>
<td>500</td>
</tr>
<tr>
<td>Post-finisher</td>
<td>10.5 - 12.0</td>
<td>90 - 100</td>
<td>3000</td>
<td>200</td>
<td>15.00</td>
<td>150</td>
<td>650</td>
</tr>
</tbody>
</table>

Reference: Brand (2004a)

According to the information presented in Table 2.1, it can be calculated that an additional 30% of the total feed normally required to reach 90 kg is needed to increase live weight from 90 to 100 kg. This results in higher feed costs as slaughter age progresses. Bezuidenhout (1997) suggests that if ostriches are initially fed according to their growth
potential, the favourable feed conversion will result in good weight gain and consequently cheaper rations can be fed from 8 to 10 months of age.

Scientific information on the nutrient requirements of ostriches during different growth and production stages is scarce (Brand, 2004a). Brand, Brand, Nel, Van Schalkwyk & Salih (1999) point out that animal nutritionists do not agree on the nutritional standards that should be used for ostriches. Current information provides only general guidelines for the protein, amino acids and energy content of diets for growing ostriches in relation to the relative nutrient requirements during different growth and production stages (Brand et al., 2002a). This information is important for the ostrich industry in order to remain competitive and economically viable. Several experiments in the field of ostrich nutrition are being done at the Ostrich Research Unit of the Elsenburg Agricultural Research Centre in South Africa to try to find the best way to achieve the ideal nutritional standards for ostriches.

Brand et al. (2002a) recommend that ostrich diets should be formulated on the principle of least cost as the prices of raw materials in relation to their nutritional value will always determine the final composition of the diet. Overall greater efficiency in the ostrich production system, across all aspects of nutrition, management and slaughter age, will result in a substantial saving in feed unit costs. The high feed costs therefore make meat production an uneconomical enterprise, given the traditional slaughter age of 14 months.

2.4 END PRODUCTS OF AN OSTRICH ENTERPRISE

2.4.1 Meat production

The ‘thigh’ has the greatest meat content of the whole carcass. The term ‘thigh’ is used arbitrarily to indicate the complex of episkeletal musculature from the pelvis, the anatomical basis of the femur and tibia (Paleari, Corsico & Beretta, 1985). The muscle Iliotibularis lateral, and muscle Iliofibularis, as identified by Mellett (1985; 1992; 1993) and Sales (1994), are of economic importance and identifiable in the thigh of an ostrich carcass. The carcass yield of ostriches depends on their size at slaughter. In South Africa an average carcass yields 25 kg of lean meat, in the USA 34 kg of lean meat, 9.2 of fat and 27 kg bones (Sales, 1997c).
Ostrich meat is perceived and marketed as a healthy alternative to other red meats due to low intramuscular fat content (Table 2.2) and favourable fatty acid profile (Table 2.3) (Mellett, 1992; Sales, 1994). Jarvis (1997) and Lambrechts & Swart (1998) referred to ostrich meat as a product of superior quality in comparison to other meat types, being characterized by low cholesterol as well as being excellent for cooking, blending and processing. Other advantages of ostrich meat are that age (within the slaughter ages of 10 – 14 months) has no effect on meat quality, and different muscles have the same taste and tenderness (Lambrechts & Swart, 1998).

2.4.1.1 Nutritional characteristics of ostrich meat

The ostrich is a credible competitor in the red meat market in that it produces nutritional and well-sought-after meat for health conscious consumers. Table 2.2 gives a summary of all the data obtained by various researchers on the moisture, protein, ash content and other significant nutritional features of ostrich meat from different sub-species and muscle types.

<table>
<thead>
<tr>
<th>Component</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>65.8 - 77.7%</td>
</tr>
<tr>
<td>Protein</td>
<td>20.5 - 22%</td>
</tr>
<tr>
<td>Fat</td>
<td>0.27 - 3.1%</td>
</tr>
<tr>
<td>Ash</td>
<td>1.0 - 1.25%</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>57 mg/100g</td>
</tr>
<tr>
<td>Sodium</td>
<td>63 mg/100g</td>
</tr>
<tr>
<td>Potassium</td>
<td>340 mg/100g</td>
</tr>
</tbody>
</table>

References: Joubert (2003); Harris, Morris, May, Lucia, Jackson, Hale, Miller, Keeton, Savell & Acuff (1993); Horbañczuk, Sales, Celeda, Konecka, Ziêba & Kawka (1998); Paleari, Camisasca, Beretta, Renon, Corsico, Bertolo & Crivelli (1998); Sales (1996); Sales (1997a); Sales & Hayes (1996); Sales, Marais & Kruger (1996).

The noticeable nutritional characteristics of ostrich meat can be exploited to increase consumer awareness of the use of alternative meats of dietetical values. The generally low
fat content of ostrich meat has made it a highly sought-after meat product especially on the international market. Additionally, consumers value the eating quality of the meat, where juiciness plays an important role (Joubert, 2003). Lawrie (1985) found that the absence of fat causes a loss of sustained juiciness during chewing, largely due to the stimulatory effect of fat on the secretion of saliva and leaves the consumers with the notion of a dry product. The results by Horbañczuk et al. (1998) and Sales (1994) however, substantiate that there are differences pertaining to the fat content between different sub-species and different muscle types.

Horbañczuk et al. (1998) discovered that the ostrich sub-species of Blue Necks have higher fat content than the Red Necks for both the muscle gastrocnemius and the muscle iliofibularies. On the other hand, Sales (1994) found that the fat content for the different muscles types varies between 0.27 % for the muscle gastrocnemius pars interna and 0.82 % for the muscle flexor cruris lateralis.

Paleari et al. (1998) reported a slightly higher protein content in ostrich meat, as compared to beef and turkey, though Sales & Hayes (1996) found that beef has higher protein content than ostrich meat in their comparative study. Sales (1996) found 1 % difference in protein content between different muscle types while Harris et al. (1993) found 2 % difference, with values being approximately 3 % higher than those of Sales (1996). No data could be found, however, for different slaughter ages and sub-species. Paleari et al. (1998) and Sales & Hayes (1996) reported higher moisture content values for ostrich meat than for beef, chicken and turkey. Sales & Hayes (1996) found that the ash content of ostrich meat is higher than both beef and chicken. On the contrary, Paleari et al. (1998) found that the ash content of beef is higher than that of ostrich meat. Sales (1996) reported slight but significant differences between the different muscle types, and slightly higher variations were noted by Harris et al. (1993).

Sales (1995a) first reported that cholesterol content does not differ largely between species, but after further research Sales (1998) noted that cholesterol content differs significantly between the muscles of African Black ostriches. On the other hand, Horbañczuk et al. (1998) reported that cholesterol content does not differ significantly between meat from red-neck (64.27 mg/100g) and blue-neck (67.01 mg/100g) ostriches. The low sodium content of ostrich meat has a distinct advantage for people who have to maintain
a low-sodium diet (Sales, 1999). Sales & Hayes (1996) reported a mean of 269 mg/100g Potassium and 43 mg/100g Sodium respectively for muscle *iliofibularis*, muscle *femorotibialis medius* and muscle *gastrocnemius* pars interna from seven South African black ostriches aged 12 – 14 months.

Ostrich meat is higher in poly-unsaturated fatty acids than beef, broiler or turkey (Sales, 1996). Table 2.3 indicates the ranges of fatty acid values in ostrich meat. Age, species and muscle difference are incorporated in the table.

**Table 2.3** Mean fatty acid ranges for ostrich meat from different ages, species and muscles.

<table>
<thead>
<tr>
<th>Fatty acids</th>
<th>Contents (g/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated:</td>
<td></td>
</tr>
<tr>
<td>Palmitic acid</td>
<td>18.5 - 26.5</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>11.0 - 16.5</td>
</tr>
<tr>
<td>Mono-unsaturated:</td>
<td></td>
</tr>
<tr>
<td>Palmitoleic acid</td>
<td>3.0 - 5.5</td>
</tr>
<tr>
<td>Oleic acid</td>
<td>27.0 - 34.0</td>
</tr>
<tr>
<td>Gondoic acid</td>
<td>0.2 - 1.2</td>
</tr>
<tr>
<td>Poly-unsaturated:</td>
<td></td>
</tr>
<tr>
<td>Linoleic acid</td>
<td>5.0 - 18.5</td>
</tr>
<tr>
<td>α-Linolenic acid</td>
<td>0.4 - 6.5</td>
</tr>
<tr>
<td>γ-Linolenic acid</td>
<td>0.4 - 1.0</td>
</tr>
<tr>
<td>Arachidonic acid</td>
<td>0.9 - 8.5</td>
</tr>
<tr>
<td>Eicosapentaenoic acid</td>
<td>0.4 - 2.0</td>
</tr>
<tr>
<td>Docosapentaenoic acid</td>
<td>0.3 - 1.0</td>
</tr>
<tr>
<td>Docosahexaenoic acid</td>
<td>0.5 - 2.0</td>
</tr>
</tbody>
</table>


Although the percentage of individual fatty acids differed significantly between ostrich muscles and variations were found within muscles, the percentage of total saturated, mono-unsaturated and poly-unsaturated fatty acids seems to be relatively constant between muscles (Sales, 1999). The meat of older animals contains more fat than that of younger animals (Lawrie, 1985) and thus contains a higher percentage of saturated fatty acids and less poly-unsaturated fatty acids (Cameron & Enser, 1991). Although the total percentage of saturated fatty acids and total mono-unsaturated fatty acids was similar in two muscles.
between red-neck and blue-neck ostriches, the total percentage of poly-unsaturated fatty acids was slightly higher in blue-neck (23.78 %) than in red-neck (23.65 %) in the muscle *gastrocnemius*, but not in the muscle *iliofibularis* (Horbańczuk *et al.*, 1998). Hoffman & Fisher (2001) and Fisher, Hoffman & Ferreira (1998) noted differences in the fatty acid content within birds of different ages. However, the birds that were involved in that study were over the maximum slaughter age of 10 – 14 months.

2.4.1.2 Physical properties of ostrich meat

Consumers generally determine the quality of meat according to a combination of characteristics that define the level of acceptability (Kramer & Twigg, 1962). These include: sensory evaluation according to colour (visual appearance) when meat is bought; flavour when meat is cooked; and juiciness, taste and tenderness which are evaluated over the short period of consumption (Smith, Carpenter, King & Hoke, 1970). Sales (1994) believe that these characteristics are influenced by animal age, sex and practices normally related to the improvement of meat quality, namely: type of boning, electrical stimulation and ageing.

**Colour**

Colour is usually the first attribute of meat observed by the consumer (Joubert, 2003; Sales, 1999). Colour is commonly defined mathematically by the Commission International del’ Éclairage (CIE) or Hunter formulas where L* measures the brightness, a* measures red-green range and b* defines the blue-yellow axis (Joubert, 2003). The red meat colour is mainly the result of the presence of myoglobin, which accounts for approximately three-fourths of the pigment in red meat. The meat colour is also dependent on external factors such as species, breed, sex, age, nutritional status and exercise (Lawrie, 1985).

Ostrich muscles are slightly dark red to slightly cherry-red (Table 2.4), in comparison with beef which is slightly cherry-red to moderately cherry-red (Morris, Harris, May, Jackson, Hale, Miller, Keeton, Acuff, Lucia & Savell, 1995). Ostrich meat is dark red in colour and when cooked is similar in appearance to cooked beef (Joubert, 2003). Naudé, Van Rensburg, Smit, Striemie, Dreiyer, Rossouw, & De Jager (1979) reported the pigment content of ostrich meat as 104-153 mg Fe/g, compared with 69 mg Fe/g in beef muscles from animals of comparable age. Sales (1996) recommended the separation of ostrich
muscles in comparable colour groups, not only in the marketing of whole raw muscles, but also to reduce variation in the visual appearance of the final processed products.

Table 2.4 Mean and standard deviation of colour parameters in raw and cooked meat tenderness (shear force) in ostrich, turkey and beef meat.

<table>
<thead>
<tr>
<th></th>
<th>Ostrich n=20</th>
<th>Turkey n=13</th>
<th>Beef n=10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour parameters:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L*</td>
<td>36.74 ± 3.6</td>
<td>64.43 ± 2.8</td>
<td>33.74 ± 2.9</td>
</tr>
<tr>
<td>a*</td>
<td>22.84 ± 2.8</td>
<td>19.30 ± 3.2</td>
<td>21.77 ± 3.1</td>
</tr>
<tr>
<td>b*</td>
<td>6.57 ± 5.0</td>
<td>3.43 ± 2.0</td>
<td>4.80 ± 1.6</td>
</tr>
<tr>
<td>Tenderness:</td>
<td>Shear force (kg/mm²)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.027 ± 0.01</td>
<td>0.021 ± 0.01</td>
<td>0.071 ± 0.02</td>
</tr>
</tbody>
</table>


Flavour and Aroma

Flavour and odour are complex characteristics influenced by texture, temperature and pH (Sales, 1999). The most important stimulants for meaty flavours include the pyrolysis of peptides and amino acids, the degradation of sugars, the oxidation, dehydration and decarboxylation of lipids, the degradation of thiamine and ribonucleotides and reactions involving sugars, amino acids, fats, H₂S and NH₃. Joubert (2003) and Paleari et al. (1995) found a characteristic aftertaste in ostrich meat, which is rarely present in beef. The sensory panel used by Harris et al. (1993) also found ostrich meat to have an aftertaste but found it to be bland. Lawrie (1985) however, suggests that the blandness might result from the high pH and low fat content, which are characteristics of ostrich meat.

Another important biological factor that influences flavour, arises during the maturing or conditioning of meat when it is held for some time after the ultimate pH has been replaced (Joubert, 2003). Lawrie (1985) found that during this period the meat becomes tender and the flavour develops. The age of the animal is another factor that plays a role in flavour (Joubert, 2003). However, no data could be found on the age effect of ostrich meat raised in the same environment but slaughtered at different ages.
**Water-holding capacity**

Water-holding capacity is the ability of meat to keep water during the presence of external forces, for example: cutting, mincing and heating (Sales, 1999). Pre-cooking appearance, cooking ability, juiciness during chewing, tenderness, texture, drip on freezing and the total amount of saleable meat are all influenced by the water-holding capacity of the meat (Barge, Destefanis, Pagano Toscano & BrugiaPaglia, 1991; Trout, 1988). Sales (1999) reported the water-holding capacity of ostrich meat cooked at 60°C and 80°C respectively as 54.97% and 41.51%.

As the pH increases, the water-holding capacity also increases and the moisture loss decreases (Joubert, 2003). Over time, ostrich muscles gradually lose moisture in a vacuum package whether refrigerated (2°C for 14 days) or frozen (-20°C for 4 months) (Sales, 1999). The water-holding capacity of the meat will then affect the juiciness of the meat as measured by a sensory panel (Penfield & Campbell, 1998). Loss of water and salt-soluble protein can decrease the water-holding capacity and binding ability of muscles when used in processed products (Chin & Keeton, 1997).

**Tenderness**

Tenderness is the most significant characteristic of quality sought by the average consumer in meat. The ultimate evaluation of tenderness is, therefore, subjectively determined by the consumer (Sales, 1999). Forrest, Aberle, Hedrick, Judge & Merkel (1975) and Sales (1999) referred to tenderness as the ease of shearing or cutting during mastication, whilst texture is related to the mealiness, greasiness, softness, and structural fineness of the meat before and after mastication. Tenderness of meat depends on the amount and taste of three types of protein: the connective tissue (collagen, elastin, reticulin and mucopolysaccharides of the matrix), myofibrils (actin, myosin and tropomyosin), and sarcoplasm (sarcoplasmic protein and sarcoplasmic reticulum) (Bailey, 1972). Furthermore, Currie & Wolfe (1980) identify the interfibre water content and the extent of the contraction of actin, myocin and the tropomyosin components of the myofibrils as other factors that play a role in meat tenderness. The Warner-Bratzler Shear force (WBS) device is used to record meat tenderness objectively (Sales, 1999). This machine works on the principle that meat becomes tougher as more force is required to cut a core of meat in half (Lawrie, 1991).
According to taste panelists on ostrich meat in South Africa, there are no significant differences between tenderness of the muscle *iliofibularis*, the muscle *iliotibialis lateralis* and the muscle *femorotibialis medius* which are of economic importance (Mellett & Sales, 1997). WBS values indicated no significant difference in tenderness of meat derived from birds of either 8, 10, 12, and 14 months of age (Sales, 1994; Mellett & Sales, 1997). In contrast to the results obtained by the WBS device, taste panelists found meat from 8-month-old birds significantly tenderer than meat from 10, 12 and 14–month-old birds and meat from 10–month-old birds more tender than that of 12 and 14-month-old birds (Mellett & Sales, 1997). Marks *et al.* (1998) found that ageing had very little effect on tenderness values of various muscles types. These results indicated that tenderness of ostrich meat is not significantly affected by age between the slaughter ages of 8 and 14 months.

**pH.**

A striking characteristic of ostrich meat is the relatively high hydrogen ion concentration measured 24 hours (pH) after the animal is bled (Joubert, 2003; Sales, 1999). The pH of living muscles is around 7.2, but when the animal dies glycogen is broken down by anaerobic glycolysis, producing lactic acid that causes a drop in pH (Lawrie, 1985; Sales, 1999). If a slow slight drop in pH occurs over a period of time, the meat will have a dark colour, high water-holding capacity and a limited shelf life (Joubert, 2003). This dark, firm and dry condition is associated with the depletion of glycogen in the muscles and it is common in animals that are stressed before slaughter (Hoffmann, 1988).

Post-mortem glycolysis, as described by the decline in muscle pH, has been investigated in several ostrich muscles (Sales & Mellett, 1996). Whilst the muscle *gastrocnemius pars interna*, the muscle *femorotibialis medius*, the muscle *iliotibialis lateralis* and the muscle *iliofemoralis* showed the typical pattern of slow pH decline, the muscle *ambiens* and the muscle *iliofibularis* showed a very rapid decline in pH until 2 hours post-mortem, when the pH again increased (Joubert, 2003; Sales, 1999). In comparison to beef, ostrich meat can be classified as an intermediate meat type, ranging anywhere between normal (pH=5.5) to extremely dark, firm and dry (pH>6.2) meat types (Sales, 1999). The high pH will put a restriction on the shelf life of ostrich meat, as meat of pH near 6.0 is considered unsuitable for holding because of microbial spoilage and undesirable odours (Sales, 1999). No data could be sourced about the relation between the pH of ostrich meat and slaughter age.
2.4.2 Skin production

Exotic leather is one of the main products derived from the ostrich industry in South Africa (Van Zyl, 2001). Unlike bovine hide, ostrich skin is not a by-product of the meat industry but rather the ostrich meat is a by-product of the leather industry (Ballard, 2001). Ostrich leather contributes about 60 to 70 % of the total income generated from a slaughter ostrich (Brand, 2004b). Therefore, producers are under increasing pressure to deliver quality skin in order to be profitable (Meyer et al., 2002).

2.4.2.1 The appearance of the ostrich skin

The hide of the ostrich is distinctive for the diamond-shaped ‘crown’ containing the highly-valued quill pattern that extends along the back and down to the wing fold and stomach quill. The crown area is presented as (A1, A2, A3, and A4) in Figure 2.1

Reference: Ostrich Emporium (1994)

**Figure 2.1** The image of an ostrich skin illustrating the follicle area, wing fold and stomach

The occurrence of nodules on the ostrich skin, as determined by the feather follicles, add to the unique appearance of ostrich leather (Cloete et al., 2004). The quill sockets are age dependent, appearing large in older birds (Holtzhausen & Kotzé, 1990). The skin of the cock is metallic blue whilst that of the hen is grey (Cooper, 2001). The corium is reptilian in
appearance and is found on the volar surface of the feet, thighs and, to a lesser extent, in other areas. The skin of the legs resembles that of crocodile leather (Sales, 1999).

2.4.2.2 Yield of skin from the ostrich

At 14 months of age an ostrich can yield a skin measuring 120 – 160 dm² (13 – 15 square feet). Until recently ostriches were traditionally slaughtered when they were 14 months old, had a live mass of at least 75 kg and a skin area of 125 dm² (Smith, Cillier, Mellett, & Van Schalkwyk, 1995; Jarvis, 1997; 1998b). Zimbabwe was the first country to start slaughtering birds when they were between 9 and 10 months old (Cooper, 2001). Studies on African Black ostriches showed that the bird weighed about 95 kg at 10 months of age (Cooper, 2001). Weight gains above this age resulted in hides exceeding 145 dm² for which no additional money is paid (Cilliers, 1998). Mellett (1995) however, advocates that the ideal age to slaughter ostriches should be 14 months to ensure ideal follicle shape. This however, is at variance with achieving optimal size at 10 months (Jarvis 1997). Jarvis (1997) argues that comparison of the skin of a given area of two birds weighing 90 kg aged 10 and 14 months reveals that the spacing between the quills is approximately equal. Nutrition plays a fundamental role in skin quality and under-nourishment possibly offers an explanation for the low skin grades found in birds between 9 and 10 months of age (Swart & Kemm, 1985). Some markets require skins from younger birds, and this emphasizes the need to pioneer and promote markets for ostrich leather from birds slaughtered at the most economic stage of their growth (Cooper, 2001).

2.4.2.3 Quality parameters of ostrich skin

Leather quality is primarily defined by the absence of damage or defects to the skin’s surface (Meyer, 2003). Mellett (1995) describes hide quality criteria that include: optimal size, absence of damage, average size, rounded follicles, and sufficient strength. Swart (1981) mentions in his study that skin size, proper and prominent quill development, skin thickness, the distribution of quills and defects or scratch marks on the quill area, are the main determinants of ostrich skin quality. Cloete et al. (2004) have identified nodule size and shape as important aspects of skin quality which tanneries have recently added to determine grading and therefore the value of the skin.
According to Mellett (1995), optimal size can be obtained with 160.6 pound (72.8 kg) birds at about 10 months of age. However, the ideal shape of the follicle can apparently not be achieved before the age of 14 months. The optimal thickness has not been defined but thickness is important as it relates to strength and is also related to animal age (Angel et al., 1997). It is unclear from the literature if any specific studies relating age, bird weight and hide quality have been done. It is also unclear from the literature what experimental basis exists for the concept of a 14-month minimum age for maximum quality.

2.4.2.4 Grading of tanned ostrich skin

Ostrich skins are graded according to specific quality parameters, with poor quality skins fetching lower prices. A system of grading ostrich skins based on the standard set by the National Ostrich Producers of South Africa (N.O.P.S.A) has been generally accepted. The aim of grading is to establish a minimum standard for each grade. A defect in the skin can be a hole, a scratch, a loose scab, a healed wound, bacterial damage, staining or sunburn. For grading purposes the crown is divided into four quarters: A1 – A4. The dividing lines between the four are 25 mm with the vertical line stretching from the base of the neck to the bottom of the crown, and the horizontal line stretching between the widest quill on either side of the crown area.

Grade one
1. A defect in one of the quarters, as long as it is not larger than approximately 40 mm x 40 mm;
2. A minimum of three-quarters of the skin free from defects;
3. Defects on the cutting lines do not affect the grade.
4. Less visible scars are permissable as long as they are outside the crown area.

Grade two
1. A skin with defects affecting two quarters and a minimum of half the skin free from defects
2. Visible defects outside the crown area will not affect the grading.
Grade three
1. A minimum of one quarter of the skin free from defects;
2. Visible defects outside the crown area are permissible.

Grade four
1. A minimum of one quarter of the skin free from defects;
2. Extensive visible defects outside the crown area are permissible but will affect grading.

Trimming
1. Neck will be trimmed 20 cm above the featherline.
2. Leg will be trimmed in the middle of the “knee”.

General
Neither colour variations nor tannage are elements which affect the grading of leather but it is the prerogative of both buyer and seller to discuss price adjustments. Hair follicles are genetically-caused defects and an extensive occurrence in at least two quarters will cause downgrading by one grade. Pinholes are externally caused by bacterial damage and an extensive occurrence in at least two quarters will also result in downgrading by one grade. A skin is a “torn” skin when a tear extends into the crown. A natural scar is a healed scar and will remain a defect. Rough surface is damaged grain. “Loose grain” is where the grain is separated from the “base” of the leather. “Vein marks” are defects if they are very obvious and cover a substantial area of the skin.

Skin is graded from A to E according to size in square decimetres (dm²):
A. 120+
B. 100 – 119 Price 10% less than A
C. 80 – 99
D. 50 – 79
E. 30 – 49

2.4.2.5 Maximising ostrich skin quality

Managing skin damage to stabilize income from slaughter birds is a major objective of the ostrich industry. In a study by Nel, Cloete, Lambrechts & Clark (2000), certain factors, like excessive handling, paddock size, and the inexperience of the producer, were
identified as being associated with skin damage. It is speculated that the high prevalence of scratch and kick marks on ostrich skins are related to the onset of puberty and associated behavioural changes during this time (13 – 14 months of age) (Meyer, 2003). This is confirmed by reports of birds slaughtered at either 10 or 14 months of age, yielding 70 % and 40 % first grade skins, respectively (Van Schalkwyk, 2003).

Although, the size, shape and distribution of quills are alleged to contribute to the marketability of the skin, no formal standards are available (Cloete et al., 2004). A study conducted by MacNamara, Nicholas, Murphy, Riedel, Goulding, Horsburgh, Whiting & Warfield (2003) revealed that markets in the United States, Spain, Italy, and Japan have a preference for a specific quill size and skin size that is obtained from older birds. It is therefore argued that the size and thickness of the skin, quill development and quill distribution is more related to the traditional slaughter age of 14 months (Boast, 1997; MacNamara et al., 2003; Mellett, 1993; Ostrich Emporium, 1994; Swart, 1981; Van Waart, 1995; Van Zyl, 1995, 2001).

According to Cloete et al. (2004) nodule size increases by 0.08 mm per month as slaughter age increases, however, nodule number decreases at a rate of 2.8 nodules/dm² for each month increase in slaughter age. Skins from males have a slightly higher average nodule size than those of females (3.68 ± 0.03 vs 3.62 ± 0.03 mm respectively), but nodule density is unaffected by gender (Meyer et al., 2004).

Snyman and Jackson-Moss (2000) define tensile strength as the force required for the breaking of a dumbbell-shaped leather piece on the Instron. The sample was pulled apart by a clamp attached to its base and another clamp inserted through the slit. The point at which the slit started to tear was defined as the slit tear strength. Cloete et al. (2004) found that tensile strength increases by 0.43 N/mm² with an increase of one month in slaughter age. An increase in skin thickness per month of age at slaughter amounted to 0.05 mm per month. No significant trends were obtained for elongation and slit tear strength (Cloete et al., 2004). Angel et al. (1997) also stated that tensile strength of ostrich skins is very high regardless of age.

Cloete et al. (2004) suggest that unless it is possible to alter the physical appearance of the nodules, for example by nutrition or breeding, producers may need to market ostriches
at relatively high ages; namely between 12 and 14 months of age. Such a strategy is likely to result in poorer grading, unless skin damage can be prevented in some way.

2.4.3 Feather production

In 1877 the best feathers on the European market were those from wild ostriches and consequently, the Cape imported wild ostriches from Barbary and Syria between 1876 and 1903 so that better feathers could be developed through crossbreeding (Smit, 1963). This led to the development of famous bloodlines and strict selection for feather quality. The feather industry was very labour-intensive and utilized the plentiful supply of cheap labour in South Africa for the plucking (carried out on live birds) and grading of the plumes (Adams & Revell, 2003). After the collapse of the feather industry in 1881 and again in 1914 (Van Zyl, 1996a), many birds were released back into the wild, with the exception of the Little Karoo where farmers kept their birds of better quality, hoping for a revival in the feather industry (Nel, 1996).

The ostrich industry subsequently experienced an upsurge of interest in other products for marketing following several attempts to regenerate the feather industry. The feather industry was therefore neglected in terms of further research as well as development of feathers of good quality, since the emphasis shifted away from feathers to the production of leather and meat.

2.4.3.1 The life-cycle of ostrich feathers

The entire covering of feathers on the bird is called the plumage. Four different types of feathers can be distinguished in the life cycle of the ostrich (Duerden, 1909, 1911; Sales, 1995c, 1997b, 1999):

1. Natal or birth plumage: these feathers consist of small tufts of rather stiff rays or barbs, differing in length, starting from about the same level, with no central level and no quill. About a week or two after hatching, the natal feathers begin to be pushed out of the feather socket by the chick feathers growing below.
2. Chick plumage: these feathers begin to appear soon after the chick is hatched and are complete at the age of about 8 months. No differences have been noted between sexes.
3. Juvenile plumage: from 4 - 5 months of age, the feathers on the body of the chick are pushed out gradually, one at a time and are replaced by larger juvenile feathers. From 8 to 9 months of age the chick begins to lose its mottled appearance. All juvenile feathers are fully ripe at the age of 16 months, the last to ripen being the wing quills. Slight sexual distinction can be seen: body feathers are darker in females than in males.

4. Adult plumage: sex differences are most distinct in the adult plumage reached when the birds are about two years old. The tail quills of the male are white below and yellowish brown above, while those of the female are a mottled light and dark grey.

Duerden (1909) and Sales (1995c; 1999) describe the types of ostrich feathers as follows: the first crop of wing quills grown by the chick, are feathers which taper towards the tip in a spear-like manner, and are known as spadonas. Body feathers, occurring over the body and wings, determine the general shape of the bird, and overlap to protect the skin as well as help to maintain body temperature.

The largest single row of feathers in the wing consists of the quills or remiges. The primaries are attached to the finger bones of the wings and the secondaries are attached to the ulna. These feathers (about 24 in number on the first row of each wing) are called whites in the male and feminas in the female. Bycocks, or fancies, are the four to five partly coloured wing quills towards each end of the male wing, and are called drabs in the case of females. They are arranged in rows of wing coverts above the wing quills. The lower wing coverts, collectively known as floss, are the light and fluffy feathers arranged in a single row which cover the wing quills. The tail quill feathers or rectices cover the stumpy tail. Hair-like filoplumes (hair feathers) are found on the skin around the wing and tail quills.

**2.4.3.2 Handling of ostrich feathers**

Ostrich feathers are exposed to various types of damage, such as wear and tear, rain, pecking by other ostriches and physical damage due to inappropriate kraal and camp facilities with undesirable vegetation. The primary cause of physical damage to feathers is due to external parasites, which can result in huge economic losses if there is no adherence to a strict spraying programme. Feather lice gnaw the flue and cause a thin moth-eaten
appearance. Feather mites penetrate the quill and damage the young growing feather. This results in the appearance of scars on the full-grown feather. The first spraying against lice and mites is done at 3 – 4 months. Spraying is repeated 2 weeks later in order to kill possible lice from eggs that have hatched in the interim. Further spraying takes place at 3-month intervals for consistent control. Spraying must be done thoroughly and care must be taken that the birds are thoroughly wet. No spraying should be done on either extremely hot or extremely cold days and birds should never be sprayed in their beaks or in open feather shafts (i.e. immediately after plucking).

2.4.3.3 Feather harvesting

At the age of approximately 6 months, the fully ripe wings/spadonnas and the tails are clipped. At the age of 8 – 9 months, the dried shafts of the fully ripe wing and tail feathers are plucked, and the ripe bodies are harvested (Sales, 1999). It is important that the feather quill marks on the buttocks as well as the body are not visible during the harvesting of the bodies. Excessive removal of body feathers in winter may lead to cold exposure with the attached risks and in summer it may lead to sunburn (hide) which can result in permanent scars to the skin. Feathers are plucked again at 14 months of age. The long green feathers have to be removed when cleaning at eight months (Sales, 1995c). The correct method of feather harvesting is to support the shaft opening between the thumb and index finger and to remove the shafts one at a time.

An adult ostrich can yield from 1 to 1.2 kg of short feathers and 400 to 450 g of white plumes (Holtzhausen & Kotzé, 1990), whereas slaughter birds produce around 700 g of body feathers (Swart & Kemm, 1985). From the earliest days of the ostrich feather industry, the procedure for removal of feathers received close attention (Sales, 1995c). The question was whether the feathers should be plucked or clipped. According to Douglass (1881), plucking (removal of the whole feather from the socket by hand) before the feather is ripe causes bleeding, and successive growth is then shorter and the quill stiffer. Regular plucking can only be maintained under the most favourable conditions of weather and food supply (Sales, 1995c; 1999).
2.4.3.4 The characteristics of good quality feathers

Duerden (1910) declared that better nutrition and management, as well as selective breeding, will cause the feathers of tame ostriches to be of a much better quality than those of wild ostriches, which dominated the markets in 1877. By the year 1911, the Cape feathers were the best on the market, due to breeding experiments for feathers of superior quality (Sales, 1995c). With proper care and management an ostrich will continue to give a consistently good feather crop for about 35 years (Duerden, 1910). However, experiments ceased with the collapse of the feather market in 1914 (Smit, 1963).

Wagner (1986) suggests that the best feathers are produced between the ages of 3 and 12 years. Nel (1996) believes that the conversion to leather and meat production in a feedlot system was detrimental to the production of feathers of good quality, because in the past, ostriches for feather production had been kept mainly on lucerne pastures. Duerden (1909) identifies the valuable characteristics of quality feathers as: length, breadth, lustre, shape, shaft thickness, and density, strength and rigidity of flue as well as absence of bars and other defects. As far as marketing is concerned, Swart et al. (1984) agree that these are the dominant factors controlling the price of fashion feathers.

2.5 THE ECONOMICS OF SLAUGHTER OSTRICHES

The profitability of ostrich farming, especially slaughter ostriches, needs to be determined and evaluated, but unfortunately there is not much reliable research on the economics of ostrich farming at micro level (Van Zyl, 2001). The ostrich industry is a fast-growing industry. The market for leather with specific qualities is expanding to the motor industries, while the demand for healthy ostrich meat is also increasing worldwide (Brand, 2004a). With South Africa being the world’s largest ostrich producer, producing approximately 60% of the total number of ostriches slaughtered annually worldwide, almost 90% of all South African ostrich products (i.e. leather, meat and feathers) are destined for the export market (Lambrechts, 2004). The profitability of the commercial ostrich production system is largely influenced by the yield and quality of the end products, feed costs and the type of production system used. Economic studies (Van Zyl, 1995; 1996b; 2001) have illustrated that the main determinants of profitability in the ostrich production system are:
1. Conversion of feed to live weight,
2. Yield of carcass at slaughter,
3. The yield of feathers, and
4. The percentage of first grade hides.

Tuckwell (1999) suggests that the profitability of the ostrich enterprise is determined by careful consideration of economies of scale, production costs, management practices and the sale price of stock processed.

The emphasis on producing primarily for the export market, with high input costs and a volatile exchange rate, consequently necessitates commercial farmers producing slaughter ostriches as cost effectively as possible (Lambrechts, 2004). Despite increasing international interest in ostrich farming (Van Zyl, 1995), over-production in South Africa since 1993 (Deeming, 1999) and the out-breaks of bird flu (H5N2 strain) in South Africa, posed a threat to the South African ostrich industry and its worldwide dominance. The industry is also hampered by a lack of reliable scientific information on the nutrient requirements of ostriches, the true nutritive values of feed, as well as information on reliable nutritional management systems for ostriches (Brand, 2004a).

Better feed-to-mass-gain-ratios and shorter growth periods are vital issues because feed constitutes 80% of the cost of raising a slaughter bird (Jarvis, 1996d). The success of an intensive commercial ostrich production system will in future rely on scientific reliable feeding and management systems to ensure optimum use of feed as well as the production of end products as demanded by the market at a certain slaughter age (Brand, 2004a).

Given the more intensive production system used in South Africa, it is generally regarded as economically more viable to produce birds that can reach slaughter age at a younger age than the traditional slaughter age of 13 – 14 months. There is however considerable debate worldwide as to the effect of age on ostrich hide quality (Angel et al., 1997; Meyer, 2003; Cloete et al., 2004).

It is claimed that the slaughter age of earlier that 14 months affects the nodule spacing, (Boast, 1997), the maturity of the feather follicle, (Mellett, 1995), and therefore the quality of the skin. However, according to Jarvis (1996b), the monetary gain from any
marginal improvement from 10 months to 14 months is minimal or perhaps non-existent due
to the high prevalence of skin damage which results in the downgrading of the skins. Jarvis
(2001) suggests that by maximizing the popularity of ostrich meat on the local market at a
good price per kg carcass, and focusing on clothing and other niche markets for the ostrich
skin, the 8 – 10 month (80 – 90 kg live weight) slaughter birds can generate enough income
to cover production costs and maintain profitability.

At present, the size of the skin and its nodule characteristics are of economic
importance (Meyer et al. 2004). It can, thus, be argued that ostriches should be slaughtered
at the older age of 14 months to obtain leather of acceptable nodule trait quality. Unfortunately, skin damage tends to increase with age (Meyer et al. 2002), thereby
conceivably nullifying the possible benefit gained from nodule size (Meyer et al., 2004).

In a study by Van Zyl (2001), income and costing budget models were used to
evaluate the economics and profitability of ostrich farming. The budget models were applied
to ostrich production practices at each of the phases (pre-starter, starter, grower, finisher, and
post-finisher) of the production process (Van Zyl, 2001). These results suggested that
production parameters like the number of day-old chicks per female, chick mortality and
slaughtering realization were found to vary considerably thereby providing scope for
improvement across the industry.

Van Zyl (1996b) identifies two criteria influencing the remuneration farmers get for
their slaughter birds, namely age (14 months) and live weight. This means that the farmers
who slaughter according to live weight criteria may save on feed costs and other costs
provided the birds reach the desired slaughter weight earlier than 14 months.

A study by Van Zyl (2001) evaluated the economics of ostrich production on an
average slaughter age of 12 months only, not taking into account different slaughter age
regimes. The relationship between slaughter age, slaughter weight, hide surface area and
hide quality is important as it affects ostrich farming profitability.

2.6 CONCLUSION

The literature review reveals that feed costs contribute markedly to the total cost of
an intensive ostrich production unit. The lack of scientific information on nutritional
standards in the ostrich industry has necessitated the use of nutritional standards from the poultry industry, with the result that several nutritional-related problems, like high mortality, poor growth and leg deformities have occurred, especially in young growing ostriches. Different authors have pointed out in the literature that feed intake increases rapidly from the age of 10 months, even though the feed conversion efficiency decreases considerably.

In addition, the lack of scientific information on the nutrient requirements of ostriches during different growth and production stages has attracted enthusiastic debate on the subject of slaughter age, the potential yield and quality of the ostrich end-products, and consequently, the profitability of the industry. Based on this literature review it can be argued that ostrich meat would be in prime economic condition if slaughtered at the age of 8 – 10 months provided the local market is expanded. The literature review also showed that the nutritional content and physical properties of ostrich meat are not significantly affected by slaughter age, which means that profitability can be maximised without compromising the nutrition of the meat. It is not clear if the quality characteristics of ostrich skin are weight or age dependent. However, a live weight of 80 kg and the age of 14 months have been identified as suitable traits for good quality skin.

Given the dependence of ostrich end-products on the income contribution of an ostrich producer, and the dependence of skin and feathers on the fashion market, provisions for effective management practice of good quality feathers have been neglected. As a result, feathers contribute only a small portion towards the profitability of the ostrich industry and a suitable age for good quality feathers is not clearly defined. However, the literature review suggests that earlier slaughtering than the generally-used 14 months of age would maximise skin quality and reduce input costs of ostrich producers.

The next two chapters will examine the data and discuss the findings of this study, with regard to the effect of slaughter age on production and yield of end-products, and consequently, the economic viability of an ostrich intensive production system at different slaughter ages. The last chapter will summarize the findings of this study and make recommendations to ostrich producers with regard to profitability at different slaughter ages.
2.7 REFERENCES


Brand, T.S., 2004b. Personal communication. Elsenburg Agricultural Research Centre, Private Bag X1, Elsenburg, 7607, South Africa.


CHAPTER 3

THE EFFECT OF SLAUGHTER AGE ON THE PRODUCTION OF OSTRICHES AND YIELD OF END-PRODUCTS

3.1 ABSTRACT

The effect of slaughter age on feed intake, slaughter weight and cold carcass yield, skin surface area, dry skin grade and total feathers was evaluated in a completely randomized experimental design involving two batches (n= 81 and n= 94) of ostriches. The birds were subject to experimental treatment and fed ad libitum from the age of 4 (n= 81) and 6 (n= 94) months and slaughtered at the age of 8.5, 10.5, 12.5, 14.5 and 16.5 months respectively. There was a positive correlation between age and feed intake \( r^2 = 0.40 \), slaughter weight \( r^2 = 0.97 \), cold carcass yield \( r^2 = 0.48 \), skin surface area \( r^2 = 0.39 \), dry skin grade \( r^2 = 0.19 \) and total yield of feathers \( r^2 = 0.29 \). The dry skin grade showed deterioration as slaughter age was prolonged. Highly significant differences (P< 0.01) in slaughter weight, cold carcass yield, skin surface area, dry skin grade and total feathers were detected between the different slaughter ages. There were no significant differences (P> 0.05) between gender and slaughter weight, skin surface area and dry skin grade within the different age groups. Males had significantly higher (P< 0.05) cold carcass yield and total feather yield than their female counterparts. From this study it can be concluded that an increase in slaughter age significantly increases feed intake, slaughter weight, cold carcass yield, and skin surface area. It is also clear that an increase in slaughter age can be detrimental to dry skin grade.

**Keywords:** age, feed intake, slaughter weight, cold carcass, skin surface area, dry skin grade, feathers, slaughter age

3.2. INTRODUCTION

The demand for feathers by the fashion industry resulted in the domestication of the ostrich in the Little Karroo region of South Africa during the middle of the 19th century.
Hayes, 2002). However, the current ostrich industry no longer relies only on feather production for the fashion industry, but also on meat and leather processed from ostrich skin. It is estimated that the current contribution of leather, meat and feathers towards the commercial turnover of the ostrich industry is 50, 45 and 5 % respectively (Hoffman, 2005).

The lack and inconsistency of scientific information on nutritional feeding standards during different growth and production stages of the slaughter birds has led in many instances to sub-optimal or even uneconomical production of ostrich products (Brand, Brand, Aucamp & Kruger, 2003a). Two studies by Brand, Gous, Kruger, Aucamp, Nel & Horbańczuk (2004a) and Brand, Gous, Horbańczuk, Kruger Aucamp & Brand (2004b), reported on the significance of energy and protein concentration in ostrich feeds when optimizing the production and the saleable components of ostrich end-products. Feed costs normally contribute between 75 and 80 % of the total costs of an intensive ostrich production unit (Brand, Gous, Brand, Aucamp, Kruger & Nel, 2003b). It is therefore assumed that a reduction of costs associated with nutrition will have a major impact on the profitability of a commercial ostrich production unit (Farrel, Kent & Schermer, 2000).

In South Africa, ostriches are generally slaughtered at 12 - 14 months of age. The reason for this is based on the presumption that optimal skin size has been attained at this stage of development (Jarvis, 1998). Leather produced from birds younger than 13 - 14 months of age at slaughter is reported to have poor quality characteristics (Mellett & Randall, 1994), and development of high quality skins is thought to be age rather than weight-dependent (Smith, Cilliers, Mellett & Van Schalkwyk, 1995). The average live weight of fed ostriches at 14 months of age is approximately 110± 0.12 kg (Cloete, Van Schalkwyk & Bunter, 2002).

Ostrich skins are marketed according to the hide size and associated grading. According to Cooper (2001), an ostrich can yield between 1.08 m$^2$ to 1.26 m$^2$ of leather at 14 months of age. Atkins (1997) reported that birds with an average weight at slaughter of 88.7 kg had skin areas of between 1.20 m$^2$ and 1.53 m$^2$. Slaughtering at 14 months of age has however, resulted in additional feed costs and increased risk of skin damage (Cloete, Van Schalkwyk & Pfister, 1998). It is alleged that the high prevalence of scratch and kick marks on ostrich skins are related to the onset of puberty and associated behavioural changes during this time (Meyer, 2003).
Meat yield depends mainly on age and weight (Bunter, 2002). At the age of 14 months an ostrich can yield between 34 and 41 kg of meat (Cooper, 1999; Smith et al., 1995). However, Brand et al. (2004a) reported between 41 and 46 kg of carcass weight for ostriches slaughtered at the age of 12 months. Separable lean meat on an ostrich carcass of 55 kg constitutes 62.5 % compared to 65 % for broilers and 54 % for beef cattle (Morris, Harris, May, Jackson, Hale, Miller, Keeton, Acuff, Lucia & Savell, 1995). The yield of ostrich meat is primarily from the thighs, with cuts being made in a ratio of 66 % steaks to 33 % fillets (Hallam, 1992). Sales (1999) reported that ostriches slaughtered within a range of 8 to 14 months did not have any influence on the most important characteristics related to meat quality (pH, cooking loss, objective tenderness and proximate analysis).

Furthermore, the reason behind slaughtering at 14 months of age was the practice of harvesting feathers of growing birds at seven to eight months of age thereby ensuring a ripe feather crop with optimal follicle development at 14 months slaughter (Angel, 1996). Findings on feather traits are generally not found in the literature, although Wagner (1986) suggests that the best feathers are produced between 3 and 12 years of age. Cooper (1999) reported that a 14-month-old bird could yield between 1.4 and 1.8 kg of feathers.

The purpose of this study was to evaluate the feed intake, skin surface area, dry skin grade, cold carcass yield, and total feathers produced from ostriches slaughtered at 8.5, 10.5, 12.5, 14.5 and 16.5 months of age respectively under an intensive production system.

3.3 MATERIALS AND METHODS

3.3.1 Experimental location

The study was carried out at the Kromme Rhee Experimental Farm near Stellenbosch (Cape Wine-land area), South Africa, from May 2004 to August 2005. The experimental site is situated at longitude 18°50’E and latitude 33°51’S at an altitude of 177m above sea level, (Labuschagne, 2005). The climate at Elsenburg is typically Mediterranean, with a mean annual rainfall of 622.7 mm (30 year average) of which 84 % occurs between April and October (Labuschagne, 2005). Slaughtering took place at a European Union (HACCP and British Retail Consortium accredited) approved abattoir in Malmesbury located about 50 km from the farm. Skin processing was performed at Swartland Tannery in Wellington (South Africa).
3.3.2 Experimental animals and management

Two batches of \( n=81 \) and \( n=94 \) African Black ostriches (\textit{Struthio camelus var domesticus}) obtained from commercial ostrich producers in the Western Cape, South Africa were used as experimental animals in this study. The group consisting of 81 birds was 6 months of age, while the group containing 94 birds was 4 months old at the onset of the experiment. Birds from both groups were randomly distributed into 10 treatment groups of between 16 and 20 birds per group. Standard management practices for ostriches as applied by the Ostrich Research Unit of Elsenburg Research Centre for rearing and raising chicks were implemented. The 6 months old (\( n=81 \)) treatment group ran from May 2004 to March 2005 whilst the 4 months old (\( n=94 \)) group ran from August 2004 to August 2005. Experimental treatment and management practices were similar for both trials. A balanced feed ration (Brand & Gous, 2006) and clean drinking water were provided \textit{ad libitum}. The birds were fed a grower diet (30 – 40 kg live weight) and finisher diet (60 – slaughter weight). Diet compositions are presented in Table 3.1.
Table 3.1 Ingredient and nutrient composition of experimental grower and finisher diets provided to slaughter ostriches.

<table>
<thead>
<tr>
<th>Ingredients (kg/ton)</th>
<th>Grower Diet</th>
<th>Finisher Diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lucerne hay</td>
<td>506.9</td>
<td>754.7</td>
</tr>
<tr>
<td>Maize meal</td>
<td>350</td>
<td>150</td>
</tr>
<tr>
<td>Soybeans oilcake</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Sunflower oilcake</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>Molasses (Calorie 3000)</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Monocalcium phosphate</td>
<td>9.6</td>
<td>10.5</td>
</tr>
<tr>
<td>Salt</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Mineral &amp; Vitamin Premix</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Limestone</td>
<td>1.9</td>
<td>3.2</td>
</tr>
<tr>
<td>Synthetic Methionine</td>
<td>0.1</td>
<td>0</td>
</tr>
</tbody>
</table>

Calculated nutrient composition:

<table>
<thead>
<tr>
<th></th>
<th>Grower Diet</th>
<th>Finisher Diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME, MJ/kg feed</td>
<td>11.4</td>
<td>9.8</td>
</tr>
<tr>
<td>Crude Protein, %</td>
<td>15.1</td>
<td>14.4</td>
</tr>
<tr>
<td>Lysine, %</td>
<td>0.7</td>
<td>0.55</td>
</tr>
<tr>
<td>Methionine &amp; Cystine, %</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Tryptophan, %</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Threonine, %</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Crude fibre, %</td>
<td>15.1</td>
<td>21.6</td>
</tr>
<tr>
<td>Fat, %</td>
<td>3.2</td>
<td>2.7</td>
</tr>
<tr>
<td>Calcium, %</td>
<td>1.1</td>
<td>1.3</td>
</tr>
<tr>
<td>Phosphorus, %</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

The birds were maintained in feedlot paddocks of 30m x 40m, with fences comprising wooden poles and smooth wire strands in order to minimize skin damage. The birds in each group were weighed individually on a monthly basis by means of a mobile electric scale (Rudweigh 200®, Contry). During weighing the birds were monitored to avoid trampling and kicking. Mortality, unrelated to the experimental procedure was 8.6 % for birds in the six months group and 13 % for birds in the four months group. Feathers from the birds in both experimental groups (6 and 4 months) were harvested at the age of seven months.
3.3.3 Experimental procedure

The birds were transported to the abattoir and fasted for 24 hours before slaughtering took place. During this period fresh drinking water was available to them. Special care was taken during transportation and loading to avoid injuries and skin damage. The birds were transported by a well-trained driver at an appropriate speed in order to avoid incidences of bruising, particularly on the thighs. The trailer used for transportation was fitted with a rubber mat and padding to prevent the birds from slipping. The birds were kept standing to avoid fresh skin damage associated by trampling. A group from each (n= 81 and n= 94) batch was slaughtered at ages 8.5, 10.5, 12.5, 14.5 and 16.5 months respectively at Swartland Ostriches Ltd, a commercial abattoir at Malmesbury, South Africa.

During slaughtering the ostriches were stunned by electrical means (an 80 Volt current applied to the head through two electrodes) and slaughter weights were recorded, before they were hoisted by the legs and the throat cut to allow bleeding from the carcass. The birds were thoroughly bled for about 10 minutes in order to prevent blood being left in the skin where it decomposes and leaves conspicuous marks, resulting in the downgrading of the skin. Feathers were removed by means of manual plucking, once bleeding had been completed. Plucking of feathers was done with caution so as not to damage the quills. Cutting of the skin was initiated by means of three major incisions as described by Paleari, Corsico & Beretta (1995) and Sales & Oliver-Lyons (1996). When the skinning was complete, post-mortem examinations, sex determination and health inspections of the carcass and internal organs were done. Sections judged unsuitable for human consumption were discarded.

Once the skin, head, legs and entrants had been removed, the carcasses were weighed (warm carcass weight) before being allowed to chill for 24 hours at ± 2°C (cold carcass). After being removed from the freezer, the skins were cooled at 14 – 16°C. Thereafter, the cooled skins were placed in a solution of biocide for 30 minutes before being salted and stored at 4°C for a week. Wet salting, as documented in Van Jaarsveldt (1992), involves the spreading of 7 – 9 kg of salt over the wet surface of the skin which is laid flesh side up and separated by a layer of salt from the next skin. Skins were folded to prevent any brine from trickling out before they were sent to the tannery in a refrigerated truck.
3.3.4 Statistical analysis

For the purpose of this study, feed intake, slaughter weight, total body feathers, cold carcass weight, tanned skin surface area and dry skin grade were recorded. The effect of age on feed intake and development of cold carcass, skin surface area, dry skin grade and total feathers was analysed by simple regression using a linear model ($y = a + b \times \text{age}$). The one-way ANOVA was used to analyse the effect of age (5 levels) on slaughter weight, cold carcass weight, skin surface area, dry skin grade and total feathers. The number of observations was 155 for slaughter weight and cold carcass, 153 for skin surface area and dry skin grade and 156 for total feathers. Multifactor ANOVA was used to analyse the effect of age and gender on slaughter weight, cold carcass, skin surface area, dry skin grade and total feathers. The number of complete cases was 154 for slaughter weight and cold carcass, 152 for skin surface area and dry skin grade and 155 for total feathers. For statistical purposes mean grading was used in this study so as to get a graphical view of the different slaughter ages with regard to skin grading. The level of significance was calculated at a 5% confidence level. An effect with a probability smaller than 0.05% ($P<0.05$) was considered to be significant. All procedures are described in detail in Statsgraphics 5.1 (1991).

3.4 RESULTS AND DISCUSSION

The result of a regression analysis representing the effect that age has on feed intake is illustrated in Figure 3.1. The data clearly shows that the level of feed intake increased ($P<0.001$) between the different age groups. Furthermore, a correlation coefficient of 0.63; $P<0.001$ was recorded between feed intake and age of ostriches. On average the difference in total feed consumed between the different age groups (8.5 – 16.5 months) was 128 g/month. The feed intake increase can largely be ascribed to the increase in nutrients to sustain levels of production and body maintenance (Degen, Kam, Rosenstrauch & Plavnik, 1991).

Research results demonstrating the relationship between feed intake and age of ostriches are limited. Brand, Nel & Van Schalkwyk (2000) have recorded differences in feed intake between birds of the same age, fed different levels of energy and protein. Dietary energy level affected feed intake while dietary protein level had no effect on feed consumption. Feed intake in this study was clearly a function of age and weight as birds in both groups were fed similar diets throughout the research trials.
Figure 3.1 The effect of age on feed intake of growing ostriches reared under an intensive production system

Slaughter weights recorded at different slaughter ages are presented in Table 3.2. At 8.5 months of age the birds had (P< 0.05) lower slaughter weight than the other age groups. The 14.5 and 16.5 month old birds had (P< 0.05) higher slaughter weights than the other age groups, but they were not significantly different from each other. Although males weighed on average 1.3 kg heavier than females at slaughter, no significant differences (P= 0.526) in slaughter weight were found between males (99.0± 1.44 kg) and females (97.7± 1.48) in the present study.

The results from this study support those reported by Du Preez, Jarvis, Capanos & De Kock (1992), who in a similar study could not demonstrate a significant difference in slaughter weight between males (102.1± 3.72 kg) and females (98.4± 4.2 kg). No significant differences between gender and slaughter weight were reported in studies by Cloete et al. (1998) or Cilliers et al. (1995). The slaughter weights of both male (111.2 kg) and female (111.2 kg) birds in the latter study are heavier than those (100.2kg) reported by Du Preez et al. (1992). The difference in weights between the studies is ascribed to the difference in the slaughtering age, as birds in the study conducted by Du Preez et al. (1992) were slaughtered at 14 months of age, while those in this trial were slaughtered at 14.5 months of age.
Table 3.2. The mean and standard deviation (SD) for slaughter weight (SW) by age and gender for ostriches slaughtered from 8.5 to 16.5 months of age.

<table>
<thead>
<tr>
<th>Age</th>
<th>n</th>
<th>Mean (SW/kg)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5</td>
<td>34</td>
<td>75.2</td>
<td>2.22</td>
</tr>
<tr>
<td>10.5</td>
<td>30</td>
<td>89.8</td>
<td>2.37</td>
</tr>
<tr>
<td>12.5</td>
<td>28</td>
<td>99.0</td>
<td>2.45</td>
</tr>
<tr>
<td>14.5</td>
<td>32</td>
<td>111.2</td>
<td>2.29</td>
</tr>
<tr>
<td>16.5</td>
<td>31</td>
<td>115.6</td>
<td>2.33</td>
</tr>
<tr>
<td>Female</td>
<td>76</td>
<td>97.7&lt;sup&gt;NS&lt;/sup&gt;</td>
<td>1.48</td>
</tr>
<tr>
<td>Male</td>
<td>78</td>
<td>99.0&lt;sup&gt;NS&lt;/sup&gt;</td>
<td>1.44</td>
</tr>
</tbody>
</table>

<sup>a-d</sup> Column means with different superscripts denotes significant level at (P≤ 0.05)

<sup>NS</sup> Non-significant

The results of the analysis of variances for cold carcass weight for both male and female birds obtained at the different slaughter ages are presented in Table 3.3. Birds slaughtered at 8.5 months had significantly lower (P< 0.001) cold carcass weights compared to birds slaughtered at subsequent slaughter intervals. No differences (P> 0.10) in cold carcass weights were recorded between birds slaughtered at 10.5 and 12.5 months of age, but they were significantly different in comparison with other age groups. A similar trend was observed between birds slaughtered at 14.5 months and 16.5 months of age: they did not differ from each other in respect of cold carcass weight, but did differ significantly from the other slaughter ages. Cooper (1999) speculates that a cold carcass weight of between 34 and 41 kg is achievable in ostriches at 14 months of age, and this study supports his opinion. The average cold carcass weight did however differ significantly (P= 0.03) between male and female birds at the end of the trial. These results were unexpected, as slaughter weight did not differ significantly between male and female birds. Several factors, such as the weight of intestines and their contents, organ weight and skin weight, probably played a role (Brand, 2006). When data was re-analysed and fitted to a regression model (Figure 3.2), age had a positive (P< 0.001) effect on cold carcass weight. As would be expected, a significant (P< 0.001) correlation (r<sup>2</sup>= 0.48) was reported between age and cold carcass weight.
Table 3.3 The mean and standard deviation (SD) for cold carcass weight (kg) by age and gender for ostriches slaughtered from 8.5 to 16.5 months of age.

<table>
<thead>
<tr>
<th>Age</th>
<th>n</th>
<th>Mean (kg)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5</td>
<td>34</td>
<td>32.2\textsuperscript{a}</td>
<td>1.07</td>
</tr>
<tr>
<td>10.5</td>
<td>30</td>
<td>41.8\textsuperscript{b}</td>
<td>1.15</td>
</tr>
<tr>
<td>12.5</td>
<td>28</td>
<td>43.6\textsuperscript{b}</td>
<td>1.18</td>
</tr>
<tr>
<td>14.5</td>
<td>32</td>
<td>47.7\textsuperscript{c}</td>
<td>1.09</td>
</tr>
<tr>
<td>16.5</td>
<td>31</td>
<td>50.3\textsuperscript{c}</td>
<td>1.11</td>
</tr>
<tr>
<td>Female</td>
<td>76</td>
<td>42.0\textsuperscript{a}</td>
<td>0.72</td>
</tr>
<tr>
<td>Male</td>
<td>78</td>
<td>44.2\textsuperscript{b}</td>
<td>0.70</td>
</tr>
</tbody>
</table>

\textsuperscript{a-d} Column means with different superscripts denotes significant level at (P≤ 0.05)

Figure 3.2 The effect of slaughter age from 8.5 to 16.5 months on the mean yield of cold ostrich carcass.

The results of the mean skin surface area (SSA) and mean dry skin grade (DSG) for ostriches slaughtered between 8.5 and 16.5 months of age, the mean SSA and DSG for both male and female birds at the end of the trial, as well as the percentage skin grade by age are presented in Table 3.4. Birds slaughtered at 8.5 months of age had a significantly (P< 0.05) smaller SSA compared to those at subsequent slaughter ages. Birds slaughtered at 10.5 and 12.5 months of age did not differ significantly from each other on SSA but did differ...
significantly from birds slaughtered at 8.5, 14.5 or 16.5 months of age. Similarly, SSA did not differ between birds slaughtered at 14.5 and 16.5 months of age, but the SSA was significantly larger than that of birds at 8.5, 10.5 and 12.5 months of age respectively. Gender did not influence the mean SSA in this trial.

The effect of gender on DSG, as with SSA, showed no significant differences between the mean DSG of males (2.5 ± 0.12) and females (2.5 ± 0.12) at the end of the trials. However, the DSG of birds slaughtered at different ages showed significant variations: birds slaughtered at 8.5 months differed significantly from those slaughtered at 12.5, 14.5 and 16.5 months of age; those slaughtered at 10.5 months differed significantly from those slaughtered at 14.5 and 16.5 months; those slaughtered at 12.5 months differed significantly from age groups 8.5, 14.5 and 16.5 months respectively; and finally, the older birds (16.5 months of age) differed significantly from all other slaughter-age groups. Birds slaughtered at 8.5 months of age produced the greatest percentage of 1<sup>st</sup> grade skins. Furthermore, it is evident from the results presented in Table 3.4, that the percentage of 1<sup>st</sup> grade skins decreased as birds were slaughtered at older ages and the percentage of lower grade skins (3<sup>rd</sup> to 5<sup>th</sup> grade) increased.

**Table 3.4** Mean skin surface area (SSA), dry skin grade (DSG), standard deviation (SD), and percentage yield from 1<sup>st</sup> to 5<sup>th</sup> grade for ostriches slaughtered from 8.5 to 16.5 months of age. Mean SSA and DSG for gender are also given.

<table>
<thead>
<tr>
<th>Age</th>
<th>n</th>
<th>Mean SSA</th>
<th>Mean DSG</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; Grade</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; Grade</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; Grade</th>
<th>4&lt;sup&gt;th&lt;/sup&gt; Grade</th>
<th>5&lt;sup&gt;th&lt;/sup&gt; Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5</td>
<td>34</td>
<td>128.6± 1.85</td>
<td>1.9&lt;sup&gt;a&lt;/sup&gt;± 1.04</td>
<td>41</td>
<td>38</td>
<td>6</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>10.5</td>
<td>31</td>
<td>141.9± 1.94</td>
<td>2.1&lt;sup&gt;ab&lt;/sup&gt;± 0.92</td>
<td>26</td>
<td>45</td>
<td>19</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>12.5</td>
<td>28</td>
<td>141.0± 2.04</td>
<td>2.6&lt;sup&gt;bc&lt;/sup&gt;± 1.06</td>
<td>18</td>
<td>28.5</td>
<td>28.5</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>14.5</td>
<td>29</td>
<td>154.5± 2.00</td>
<td>2.7&lt;sup&gt;c&lt;/sup&gt;± 1.08</td>
<td>10</td>
<td>38</td>
<td>14</td>
<td>38</td>
<td>0</td>
</tr>
<tr>
<td>16.5</td>
<td>31</td>
<td>153.3± 1.94</td>
<td>3.3&lt;sup&gt;d&lt;/sup&gt;± 1.08</td>
<td>6</td>
<td>16</td>
<td>23</td>
<td>45</td>
<td>10</td>
</tr>
</tbody>
</table>

Female 77 143.4<sup:NS</sup>± 1.21 2.5<sup:NS</sup>± 0.12  
Male 75 144.7<sup:NS</sup>± 1.22 2.5<sup:NS</sup>± 0.12

<sup>a-d</sup> Column means with different superscripts denotes significant level at (P≤ 0.05)  
<sup>NS</sup> Non-significant

The results obtained for SSA in this study support those reported by Cloete <i>et al.</i> (1998). Although Cloete <i>et al.</i> (1998) did not report the effect of SSA on the age of ostriches, they did measure the skin surface area of birds with an average weight of 85.6 kg. As weight
is considered a function of age, it is to be expected that the SSA recorded in this study is similar for those slaughtered between 12.5 to 14.5 months of age. Further support is provided by results presented in Table 3.2, where findings demonstrate that no significant differences in slaughter weight were recorded between male and female birds. Therefore a difference in SSA is not expected between male and female birds with similar slaughter weights. Cloete et al. (1998) could also not establish a significant difference in SSA between male and female ostriches at specific slaughter weights. The results from the present study concur, indicating no significant difference (P> 0.10) between the SSA of male (144.7± 1.22) and female (143.4± 1.21) birds.

The quality of ostrich skin is based largely on the lack of visible skin damage (Meyer, Cloete, Brown & Van Schalkwyk, 2003a). The results presented in Table 3.4 and Figure 3.4 clearly demonstrate that skin quality decreases with the increase in slaughter age. Cloete, Van Schalkwyk, Hoffman & Meyer. (2004) ascribe the reduction in skin quality associated with age to the onset of puberty and associated increase in aggressive behaviour. Furthermore, in a study by Brand, Aucamp, Kruger & Sebake. (2003c) where one group of ostriches were fed a high level of protein nutrient and the other group received a low level of protein, the high protein nutrient group had a lower percentage of 1st grade skins than the low protein group. The lower percentage of 1st grade skins in the high protein group was ascribed to a significantly higher incidence of mounting observed in this group compared to the lower protein group. This is probably related to earlier sexual development in the group fed with high protein. As ostriches in this study were not subjected to different levels of nutrition, the increase in slaughter age and associated decrease in percentage of 1st grade skins could also be the result of the onset of puberty and related aggressive behaviour. Cooper (2000) suggests that birds should be slaughtered at a live mass of 85 – 90 kg because, above this mass, the skin value declines, as areas of smooth growth begin to dominate the hide and these are the least valuable sections. In a study by Meyer, Cloete & Brown (2003b), the heavier group of slaughter ostriches sustained more skin damage than the lighter-weight groups. Once again, no significant difference between the skin grades of male and female birds was observed.

Results presented in Table 3.4 are substantiated by data re-analyzed and fitted to a regression model (Figure 3.3). Slaughter age significantly (P< 0.001) contributes to SSA and with each increase in slaughter age the skin surface area is increased by 3.1 square decimeters. Furthermore, the high correlation (P< 0.001; r²= 0.39) indicates that an increase
in age will result in an increase in skin surface area. The results obtained in this study for SSA are consistent with those reported by Cloete et al. (2004) where it was shown that an increase in one month of age resulted in an increase of 6.2 kg in slaughter weight and a 4.2 square decimeters increase in skin surface area.

\[
y \text{ (skin area/dm}^3 \text{)} = 104.8 \text{ (dm}^3 \text{)} + 3.1 \text{ (dm}^3 \text{)} * \text{ age (months)}
\]

\[R^2 = 0.39\]

**Figure 3.3** The effect of slaughter age from 8.5 to 16.5 months on the mean skin surface area of tanned ostrich skin.

\[
y \text{ (skin/grade)} = 0.38 \text{ (grade)} + 0.17 \text{ (grade)} * \text{ age (months)}
\]

\[R^2 = 0.19\]

**Figure 3.4** The effect of slaughter age from 8.5 to 16.5 months on the dry skin grade of slaughter ostriches.
The results indicating the total amount (kg) of feathers produced from ostriches slaughtered at 8.5, 10.5, 12.5, 14.5 and 16.5 months of age respectively, are presented in Table 3.5. The amount of feathers produced by the birds at the different ages differs significantly among the 5 age groups. The birds slaughtered at 8.5 months of age produced significantly lower feather weight than those slaughtered at 10.5, 12.5, 14.5 and 16.5 months of age. Although the birds slaughtered at 12.5 and 14.5 months of age did not differ significantly from each other, they did, however, differ from the other age groups. Furthermore, gender did influence (P< 0.005) the mean weight of total feathers produced by the male (1.69± 0.03 kg) and female birds (1.46± 0.03 kg).

Table 3.5 The mean yield and standard deviation of total body feathers of slaughter ostriches slaughtered between 8.5 and 16.5 months of age.

<table>
<thead>
<tr>
<th>Age</th>
<th>n</th>
<th>Mean (kg)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5</td>
<td>34</td>
<td>0.96(^a)</td>
<td>0.05</td>
</tr>
<tr>
<td>10.5</td>
<td>30</td>
<td>1.60(^b)</td>
<td>0.05</td>
</tr>
<tr>
<td>12.5</td>
<td>28</td>
<td>1.81(^c)</td>
<td>0.05</td>
</tr>
<tr>
<td>14.5</td>
<td>32</td>
<td>1.84(^c)</td>
<td>0.05</td>
</tr>
<tr>
<td>16.5</td>
<td>31</td>
<td>1.65(^b)</td>
<td>0.05</td>
</tr>
<tr>
<td>Female</td>
<td>77</td>
<td>1.46(^a)</td>
<td>0.03</td>
</tr>
<tr>
<td>Male</td>
<td>78</td>
<td>1.69(^b)</td>
<td>0.03</td>
</tr>
</tbody>
</table>

\(^a\)\(^c\) Column means with different superscripts denotes significant level at (P≤ 0.05)

The results in Table 3.5 indicate that feather production is fairly low at 8.5 months of age, increasing to 12.5 months where it seems to stabilize between 12.5 and 14.5 months of age, and then is followed by a slight decline at 16.5 months of age.

3.5 CONCLUSION

Production traits are generally not influenced by gender in ostriches between 8.5 and 16.5 months of age. Gender did however influence the total weight of feathers produced, with male birds out-performing female birds. Although the amount of feathers produced does contribute to income generated from ostriches, skin size, skin quality and carcass weight currently contribute a significantly greater percentage of the income generated from slaughter birds. Therefore, selection based on gender for production traits does not seem
feasible. Furthermore, the results presented in this study clearly show that there is a direct correlation between age and skin size, age and carcass weight, as well as age and skin quality. This means that maintaining birds for longer periods increases both carcass and skin size, but skin quality is not as good. Feed intake and consequently cost also increases over time, therefore the ostrich producer may need to compromise in order to achieve the most effective and profitable production system.

3.6 REFERENCES


CHAPTER 4
THE IMPACT OF SLAUGHTER AGE ON THE PROFITABILITY OF AN INTENSIVE SLAUGHTER OSTRICH PRODUCTION SYSTEM

4.1 ABSTRACT

Slaughter age has demonstrated to have an important financial impact on the profitability of an intensive ostrich production system. The profitability of ostriches slaughtered at different ages was consequently investigated at the Kromme Rhee experimental farm near Stellenbosch. The birds were randomly divided into 10 groups of between 16 and 20 birds per group. Standard production practices as applied in an intensive ostrich production unit were implemented. Self-mixed diets were fed *ad libitum* to the birds. Birds were slaughtered at the ages of 8.5, 10.5, 12.5, 14.5, and 16.5 months respectively. Data on feed intake and yields of cold carcass, crust skin size, skin grade and total feathers was recorded for birds slaughtered at the respective ages. Data was analysed according to the analysis of variances. A gross margin type analysis was performed to evaluate the effect of different slaughter ages on the financial viability of each production system. Values for feed intake, slaughter weight, meat yield, and skin size yield were predicted by regression analysis based on experimental values. Industry figures and norms were used as proxy for other production inputs and costs. The relative income contribution of the three main products measured in this study, namely, skin, meat and feathers, occurred in a ratio of 47:53:0, 52:47:1, 47:50:3, 44:51:5, 39:56:5 at the respective slaughter ages. Total income revealed an increase of 26% from the 8.5 to the 10.5 month slaughter system, 4% between 10.5 and 12.5 months, and 11% between 12.5 and 14.5 months. Income dropped by 0.3% between 14.5 and 16.5 month slaughtering. Total costs increased with slaughter age, particularly feed costs which showed an increase at a decreasing rate for the different slaughter ages. The margin above specified cost per bird was highest for birds slaughtered at 10.5 months. The margin above cost showed a steady decline as birds were slaughtered at higher ages. Slaughtering at 16.5 months revealed a negative margin. To compare the effect of differences in time span between different slaughter age regimes, margin above costs for each system over 5 years was discounted to a present value. The 10.5 month slaughter age
revealed the highest present value for the margin above cost. Again slaughter at 16.5 months revealed a negative present value on the margin above cost after 5 years. Financial viability calculations are relevant and valid for data obtained in this case study. Financial viability is, however, case-specific and may vary between producers, depending on their individual management practices, production systems and cost structures. Results from this study may be of significant value for managerial decision-making in the ostrich industry.

**Keywords:** Slaughter age, ostriches, profitability, margin above specified costs, present value.

4.2 INTRODUCTION

Prominent aspects of economic interest in an intensive ostrich enterprise include, amongst others, growth and mortality during various juvenile stages, slaughter age, feed costs, meat and feather yield and leather quality characteristics (Bunter, 2002). Products generated from an ostrich enterprise are mainly leather, meat and feathers. Leather is estimated to contribute more than 50% of the total income of ostrich producers, depending on the quality of the skin. Hoffman (2005) estimates the income contribution of leather, meat and feather towards the commercial turnover of the ostrich industry as 50%, 45% and 5% respectively. The ostrich industry in South Africa is mainly export driven and its contribution is estimated as 60% of the world’s total number of ostriches slaughtered annually (Lambrechts, 2004). The main farming systems and facilities for export, slaughter and processing are located within a semi-arid region (Klein Karoo) of the Western Cape Province. This region represents 70 – 80% of the South African Ostrich Industry (Olivier & Ganzevoort, 2005).

Ostriches have traditionally been slaughtered at 14 months of age with the purpose of attaining the optimum skin size and ideal follicle shape. At 14 months of age a slaughter ostrich can produce between 1.4 and 1.8 kg of feathers, yield 34 – 41 kg of low fat, red meat, and 110 – 130 dm² of leather (Cooper, 1999). However, recent studies by Brand, Gous, Horbańczuk, Kruger, Aucamp & Brand (2004) report that ostriches slaughtered at 12 months of age yield between 1.09 – 1.2 kg of feathers, 41 – 46 kg of meat and 135 – 140 dm² of skin. This observation warrants further investigation into the effect of slaughter age on the profitability of slaughter ostriches, given the fact that ostriches slaughtered at the age of 14
months necessitate higher feed consumption and an increased risk of damage to the skin (Cloete et al., 1998). Feed costs are the greatest variable in the cost structure of an intensive ostrich production system, comprising 75% – 80% of the total costs (Brand & Jordaan, 2004). A younger slaughter age has the advantage of a reduction in feed intake by as much as 40% (Cooper, 2001). In addition, it seems that quality characteristics of ostrich meat are not affected by age between 8 and 14 months, (Girolami, Marsico, D’Andrea, Braghieri, Napolitano & Cifuni, 2003; Swart & Lambrechts, 1998)

There is an urgent need for scientific information on the economic viability of different slaughter ages in the ostrich enterprise. This information will help ostrich producers in their decision-making process and enable them to meet the market requirements for specific end-products in the most economical way.

The objective of this research study was to evaluate the profitability of different slaughter age regimes (8.5, 10.5, 12.5, 14.5 and 16.5 months respectively), with regard to the three main end-products (leather, meat and feathers) based on the production standards used in an intensive ostrich production unit. A present value analysis over a 5-year time horizon was conducted to compare profitability between the different slaughter age regimes.

4.3 THEORETICAL BACKGROUND

The purpose of economic profitability analysis is to determine whether an enterprise will contribute to the long-term profitability of the farm. Gross margin can be used to assist in assessing the economic viability of production systems with different slaughter ages. Van Reenen and Marais (1992) define the gross margin as the difference between the estimated gross production value and the directly allocatable variable costs of the specific production unit or enterprise. The gross margin represents the potential contribution of an individual enterprise to the fixed and non-directly allocatable variable costs and therefore also to the eventual profit of the whole farming enterprise (Barnard & Nix, 1979; Van Reenen & Marais, 1992; Kay & Edwards, 1999). The distinction between fixed and variable costs is important in decision-making and enterprise analyses. Fixed cost is that part of total cost that remains unchanged, regardless of the level of output and whether production takes place or not (Van Zyl, Kirsten, Coetzee & Blignaut, 1999). Variable cost is that portion of the cost component that can change within the framework of a specific production structure as the
expenses of the enterprises and/or the intensity of the unit change (Castle, Baker & Smith, 1972; Van Zyl et al., 1999). Variable costs can be managed and/or avoided more easily in the short term. They are divided into three components, namely directly allocated variable costs, indirectly allocated variable costs and non-allocated variable costs. Boehlje & Eidman (1984) suggest that only variable costs should be considered when deciding what to produce, how to produce and how much to produce in the short term. Barnard & Nix (1979) stated that the variable costs in a gross margin analysis have to satisfy two criteria, which should also be satisfied by the enterprise outputs, namely:

1. To be specific to a single enterprise
2. To vary approximately in proportion to the size of the enterprise.

It can be difficult to allocate the total costs of a farm business amongst different enterprises accurately. General practice in profitability analyses is therefore to allocate all possible costs that can be assigned to a particular enterprise with reasonable accuracy. Subtracting such costs from the gross value of production then yields the “margin above specified cost” which is a term widely used in profitability analysis in the agricultural sector (Barnard & Nix, 1979; Van Reenen & Marais, 1992; Van Zyl et al., 1999).

The profitability of an enterprise, expressed by margin above cost, may however be sensitive to various macro-economic factors that are mostly beyond the control of ostrich producers. For planning and decision-making purposes, a sensitivity analysis can be performed to account for changes that may take place due to possible fluctuating product prices and input costs (Barnard & Nix, 1979; Van Reenen & Marais, 1992). Such an analysis may assist the producer to quantify to some degree the effect of future risk and uncertainty on the margins. According to Van Zyl et al. (1999), business risk can be classified into two categories, namely, technical risk and market risk.

Technical risks refer to the possibility that the expected yield could be minimized due to uncertain climatic conditions, incompetent management skills and other biological factors. In the ostrich industry the outbreak of bird flu (H5N2 strain) in South Africa, represents such a risk as it affected the export market of ostrich products and consequently the production of ostriches. New technology and research advances could also create uncertainty and threaten the advantage that South African ostrich producers have enjoyed over the decades.
Market risks refer to developments in the market during the production process and the sale of the products (Van Zyl et al., 2005). The price that is realized may be higher or lower than the price envisaged during the planning process. As an export-driven market, the most critical variables that affect the ostrich industry are the prices of end-products and the overall increase in prices of inputs. These variables are largely influenced by an unstable exchange rate, fluctuating interest rates and the prices of crude oil. Changes in the fashion industry and consumer perception of ostriches may also bring about drastic changes in the ostrich industry.

Sensitivity analysis is a process of asking “what if” questions. It often gives the producer better insight into the probability of profitability of an enterprise, the effect of changes in prices, yield and consequently, the amount of risk involved (Kay & Edwards, 1999).

When comparing the profitability of the different slaughter age regimes, certain factors, such as the availability of chicks at any given time, the length of period till slaughtering and frequency of cash flow, need to be taken into account. An 8.5 month slaughtering system cannot merely be compared to a 16.5 month slaughtering system, because technically it is possible to raise two batches of birds under the 8.5 month system over the same period as one batch under a 16.5 month system. A comparison between slaughter age regimes therefore needs to be done over a specific time horizon. Comparing the different slaughter age regimes over a period stretching beyond the current production year means cash flows will be occur over such periods in the future. This necessitates taking into account the time value of money. The basic concept of time value is that a rand in hand today is worth more than a rand that will be received sometime in the future.

The time value of money is important in financial management because it refers to risk (the possibility that the producer will lose an entire investment or a part thereof), inflation and return on investment (what the producer will earn on an investment over a certain period of time), and links these aspects to the evaluation of opportunities (Van Zyl et al., 1999; Castle, Becker & Nelson, 1987). It integrates return and risk by comparing the long-term costs and benefits of various decisions. Discounting is one of the two types of adjustments that can be made to determine the value of money today when its value at some future date is known (Castle et al., 1987).
Present value analysis is one of the criteria commonly used in evaluating the profitability of alternative enterprises over a period of time in the future (Kay & Edwards, 1999; Barry, Ellinger, Hopkin & Baker, 2000; Boehlje & Eidman, 1984). The net present value method uses the discounting formula for a non-uniform or uniform series of payments to value the projected cash flow for each investment alternative at one point in time (Barry et al. 2000). The future value (FV) is discounted back to the present to find its current or present value (Kay & Edwards, 1999).

To determine the present value (PV) of an amount of money in future, the formula can be written as follows: (Kay & Edwards, 1999; Barry et al., 2000; Boehlje & Eidman, 1984)

\[
PV = \frac{FV}{(1 + i)^n}
\]

To determine the net present value (NPV) of cash flows of a project(s), the formula can be written as follows:

\[
NPV = \sum_{t=0}^{N} \frac{C_t}{(1 + i)^t}
\]

Where:

- \(N\) = number of years to end of project
- \(t\) = time period
- \(\sum\) = summation of all \(N\) periods
- \(C_t\) = net cash flow in period \(N\)
- \(i\) = discounting rate

The application of net present value analysis requires the use of the following steps as identified by Van Reenen & Marais (1992):

1. Determination of discount rate,
2. Calculation of the present value of the cash outlay required to launch the capital project(s) or to produce the asset(s),
3. Calculation of the annual net cash flow of the project(s) over its/their lifetime,
4. Calculation of the present value of the annual net cash flow,
5. Calculation of the net present value of the project(s),

6. Acceptance or rejection of the project, or selection of the most advantageous project.

The value often used to find the present value is referred to as the discount rate or factor (Barry et al., 2000; Van Zyl et al., 1999; Kay & Edwards, 1999). Kay & Edwards (1999) note that the discount rate is often one of the more difficult and sensitive values to estimate when determining the net present value. The discount rate is used to adjust the expected future net cash flow to its present value (Boehlje & Eidman, 1984). The discount rate may represent an opportunity cost, a cost of capital or a required rate-of-return (Barry et al., 2000). Kay & Edwards (1999) describe the discount rate as an opportunity cost of capital, representing the minimum rate of return required to justify the investment and suggest that if funds are to be borrowed to finance the investment, the discount rate can be set equal to the cost of borrowed capital. If a combination of borrowed and equity capital will be used, a weighted average of the interest rate of the loan and the equity opportunity cost should be used. This results in a weighted average cost of capital as summarized below (Boehlje & Eidman, 1984):

\[ d = k_e W_e + k_d (1 - t) W_d \]

Where:
\( d \) = discount rate
\( k_e \) = after-tax cost of equity (rate of return on equity capital)
\( W_e \) = proportion of equity used
\( k_d \) = cost of debt (interest)
\( t \) = marginal tax rate
\( W_d \) = proportion of debt

Due to risks involved in capital investments, the discount rate should be equal to the rate of return expected from an alternative investment of equal risk (Kay & Edwards, 1999). By using the cost of capital as the estimate of the discount rate in the present value analysis, the returns for a particular enterprise are evaluated in comparison with the cost of the debt and equity funds committed to that enterprise (Boehlje & Eidman, 1984). Consequently, a particular enterprise is desirable only if it will return more income than the expenses that will be incurred to finance its purchase.
Even if an enterprise is economically profitable, it might not be financially feasible. Consequently, financial feasibility analysis must be completed before a final decision is taken to accept or reject a particular project alternative (Boehlje & Eidman, 1984). An enterprise is considered to be economically viable when the present value is positive. The criterion for acceptance or rejection of an investment is simple: - for mutually exclusive alternatives, accept an investment alternative if it has a positive present value and reject the investment if it has a negative present value. However, the decision may not be one of accepting or rejecting a particular investment but of choosing among a number of alternative investments. In this situation, the investment alternatives can be ranked in order of preference, based on their present value, with the alternative having the highest present value being ranked first, and the one with the lowest present value ranked last.

The materials and methods of this study were established on the aforementioned theoretical background to determine the gross margin and calculate the present value of the different slaughter ages over 5 years.

4.4 MATERIALS AND METHODS

Experimental animals used in this study were (n= 175) South African Black ostriches (Struthio camelus var domesticus). The birds were randomly divided into 10 groups of between 16 and 20 birds per group at the age of 4 months (n= 81) and 6 months (n= 94) respectively. Standard production practices as applied in an intensive ostrich production unit were implemented. Self-mixed balanced grower diet, (min 15% crude protein, 0.68% lysine and 11.4 MJ ME per kg feed) and finisher diet (min 14% crude protein, 0.55% lysine and 9.8 MJ ME per kg feed) were fed ad libitum to the birds. Birds were slaughtered at the ages of 8.5, 10.5, 12.5, 14.5, and 16.5 months respectively. Data on feed intake and yields of cold carcass, crust skin size, skin grade and total feathers were recorded for birds slaughtered at the respective ages. Values for live weight, feed intake, meat yield, and skin size yield were predicted by regression analysis (y = a + bx) based on experimental values obtained in the study. Industry figures and norms were used as proxy for other production inputs and costs.

The margin above specified cost per bird was calculated to evaluate the profitability of each of the different slaughter age systems. The projected cash flows over five years for the five different slaughter ages were converted to present values in order to compare profitability between the different slaughter age regimes. Capital outlay of the investment
was not considered in this study. For illustrative purposes, the discount rate was set equal to the latest figures for the prime interest rate, as determined by the South African Reserve Bank (2006).

A sensitivity analysis was carried out to determine the effect of marginal changes in total income and total input cost on the margin above specified costs of the different slaughter age regimes. Due to difficulty in assessing the specific effect of certain micro-economic variables on prices of products or inputs, a set of arbitrary risk scenarios were considered where income was reduced and costs were increased by a certain arbitrary percentage.

The following assumptions have been made in the profitability analyses:

1. The economic analyses in this case study were performed per bird and each bird was assumed to be a representative of a batch at a specific slaughter age and proportional to the inputs and yield as determined in the present study. However, it can be argued that flock variables can influence the profitability of an ostrich enterprise at a specific slaughter age.

2. Labour, transport and fuel costs were considered directly allocatable costs in this case study, as their inputs, together with other directly allocatable costs, were determined throughout the different production enterprises.

3. In South Africa the annual reproduction of ostriches, over an 8-month breeding season is between June and January (Fair, Van Wyk & Cloete, 2005; Lambrechts, 2004). For the purpose of the net present value analysis in this case study, it was therefore assumed that 4-month-old ostrich chicks that are similar in quality would be available between November and June only.

4. For the purpose of comparing the present value of margins over a 5-year period, all the different production systems started in November, employing an all-in-all-out batch processing system.

5. In cases where a particular age group had not reached slaughter age at the common terminal date of 5 years, income was calculated at salvage value, based on live market prices of an age group equivalent to the age at that moment in time. Costs were based on actual costs incurred up to the common terminal date.

6. Capital outlay for the ostrich production unit was not considered in this study, only the cash flow from the margin above cost.
7. A discount rate of 11% was used in the present value analysis of this case study, being the prime interest rate determined by the South African Reserve Bank (June, 2006).

8. For the present value analysis, income and costs were adjusted annually to take into account inflationary effects. Income was adjusted based on the index of producer prices for animal products, while costs were adjusted, based on the price index of intermediate goods (Abstract of Agricultural Statistics, 2006). The year 2000 was taken as the base year.

9. For both income and costs, the assumed annual percentage change was based on the 2003/2004 indices, which are the latest published data.

Financial viability calculations are relevant and valid for data obtained in this study and are a true representation of an intensive ostrich production unit. Financial viability is however case-specific and may vary between producers, depending on their individual management practices, production systems and cost structures.

4.5 RESULTS AND DISCUSSION

As outlined in Table 4.1, the total income increased with slaughter age although there was a slight decline at 16.5 months. Additionally, Figure 4.1 gives a graphical representation of the results found in this study. The cost of 4-month chicks and feeds contributed 55 % and 25 % respectively of the total production costs. Feed costs were lowest for the 8.5 month slaughter system. The trend-line reveals that income and total costs increased with slaughter age while margin above costs decreased as slaughter age was prolonged. The birds slaughtered at 8.5 months brought in less income (R1413.88) than the other age groups. This was the result of significantly lower yields (Table 3.3 and Table 3.4) and lower prices for the respective products. Leather contributed 47 % and meat 53 % towards the total income at 8.5 months. The skin surface area affected the total price of the skins at this age because sizes were significantly smaller than those achieved in the other slaughter age regimes, although the number of first grade skins was significantly higher than the other age groups. In contrast, slaughter at 8.5 months was the second most economic slaughter age in terms of margin above specified cost (R198.30) and present value (R1226.00), (Table 4.1 and Table 4.4). The average income and costs were highest at 8.5 months over the 5-year project horizon. For present value purposes, slaughtering at 8.5 months had the most production
cycles over 5 years in comparison to the other age groups. This is important as the income received from the first production year makes a contribution towards financing the fixed costs of an ostrich producer. Slaughtering at 8.5 months was profitable even when a scenario of a 15 % increase in costs (income unchanged) was considered (Table 4.3). For a scenario where income decreased by 12 % (costs unchanged), the margin above cost was still positive. However, when considering combined risk effects (income decreased and costs increased), it was only profitable at 7 %.

Table 4.1 Gross Margin per bird for ostriches slaughtered at 8.5, 10.5, 12.5, 14.5 and 16.5 months of age under an intensive production system.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>8.5</th>
<th>10.5</th>
<th>12.5</th>
<th>14.5</th>
<th>16.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Income</td>
<td>R %</td>
<td>R %</td>
<td>R %</td>
<td>R %</td>
<td>R %</td>
</tr>
<tr>
<td>Skins&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>665.69</td>
<td>934.62</td>
<td>886.99</td>
<td>904.51</td>
<td>797.24</td>
</tr>
<tr>
<td>Meat&lt;sup&gt;3&lt;/sup&gt;</td>
<td>745.19</td>
<td>835.49</td>
<td>925.79</td>
<td>1,063.35</td>
<td>1,157.85</td>
</tr>
<tr>
<td>Feathers&lt;sup&gt;4&lt;/sup&gt;</td>
<td>3.00</td>
<td>18.00</td>
<td>52.00</td>
<td>103.00</td>
<td>109.00</td>
</tr>
<tr>
<td>TOTAL INCOME</td>
<td>1,413.88</td>
<td>1,788.11</td>
<td>1,864.78</td>
<td>2,070.86</td>
<td>2,064.09</td>
</tr>
<tr>
<td>Direct costs</td>
<td>R %</td>
<td>R %</td>
<td>R %</td>
<td>R %</td>
<td>R %</td>
</tr>
<tr>
<td>4 month chick&lt;sup&gt;6&lt;/sup&gt;</td>
<td>667.00</td>
<td>667.00</td>
<td>667.00</td>
<td>667.00</td>
<td>667.00</td>
</tr>
<tr>
<td>Feeds:&lt;sup&gt;5&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grower</td>
<td>136.68</td>
<td>136.68</td>
<td>136.68</td>
<td>136.68</td>
<td>136.68</td>
</tr>
<tr>
<td>Finisher</td>
<td>173.10</td>
<td>332.36</td>
<td>510.51</td>
<td>707.56</td>
<td>923.50</td>
</tr>
<tr>
<td>Diseases/parasites control&lt;sup&gt;6&lt;/sup&gt;</td>
<td>31.74</td>
<td>103.53</td>
<td>169.42</td>
<td>180.42</td>
<td>191.42</td>
</tr>
<tr>
<td>Labour:&lt;sup&gt;6&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permanent</td>
<td>7.31</td>
<td>10.55</td>
<td>13.80</td>
<td>17.05</td>
<td>20.29</td>
</tr>
<tr>
<td>Contract, feather service</td>
<td>11.00</td>
<td>11.00</td>
<td>11.00</td>
<td>11.00</td>
<td>11.00</td>
</tr>
<tr>
<td>Transport/farm&lt;sup&gt;7&lt;/sup&gt;</td>
<td>9.99</td>
<td>14.43</td>
<td>18.87</td>
<td>23.31</td>
<td>27.75</td>
</tr>
<tr>
<td>Slaughter fees&lt;sup&gt;6&lt;/sup&gt;</td>
<td>165.00</td>
<td>165.00</td>
<td>165.00</td>
<td>165.00</td>
<td>165.00</td>
</tr>
<tr>
<td>TOTAL COSTS</td>
<td>1,215.58</td>
<td>1,454.31</td>
<td>1,706.04</td>
<td>1,921.78</td>
<td>2,156.40</td>
</tr>
<tr>
<td>Margin Above Specified Costs (R/bird)</td>
<td>198.30</td>
<td>333.79</td>
<td>158.73</td>
<td>149.08</td>
<td>-92.31</td>
</tr>
</tbody>
</table>

Source: Computed from experimental values and industry figures.
1. Skin surface area, regression analysis (y = 104+3.1*age)
2. Skin grade, regression analysis (y = 0.38+0.17*age)
3. Cold carcass, regression analysis (y = 15.6+2.19*age)
4. Feathers, regression analysis (y = 0.47+0.09*age)
5. Feed intake, regression analysis (y = 1007+128*age)
6. Ostrich production figures used in an intensive production system at Klein Karoo (2006)
Total income increased by 26 % from 8.5 to 10.5 month slaughtering (Table 4.2 and Figure 4.1). Total costs increased by 20 %, most notably feed cost, which increased by 51 %. For the 10.5 month slaughter regime, the cost of 4-month-old chicks and feeds comprised 46 % and 32 % respectively of the total production costs. Disease and parasite control increased by 4 % between the 8.5 and 10.5 month slaughter ages. Although the trend-line pointed out that margin above cost decreases with slaughter age, it can be seen that it was the highest at 10.5 months (R333.79), showing a 68 % increase on 8.5 months. This was due to the significant increase of cold carcass and skin surface area from 8.5 to 10.5. Furthermore, the skin grading was not significantly different from 8.5 months, which means that the 10.5 months slaughtering produced a higher number of first grade skins than birds that were slaughtered at older ages.

At 10.5 month slaughtering, the contribution of skin, meat and feathers towards the margin above cost was 52 %, 47 % and 1 % respectively. This was the only slaughter age in this study where skin contributed more than meat towards the total income. This result substantiates the fact that ostrich skin is still the most economically important end-product in the ostrich industry (Hoffman, 2005). The sensitivity analysis revealed that a 20 % cost increase (income unchanged) still produced a positive margin (Table 4.3). A decrease of 17.5 % income (costs unchanged) did not negatively affect the margins, although they were substantially reduced when compared to 17.5 % cost increase (income unchanged). Furthermore, the sensitivity analysis shows that the 10.5 month slaughter system is the only slaughter age which remains profitable when combined risk effects of a simultaneous increase in cost and decrease in income (10 %) were considered. When comparing the present value (Table 4.4 and Figure 4.2) of the 8.5 and 10.5 month slaughter regimes in the 5-year plan, the 10.5 month slaughter system was 7 % higher. Birds slaughtered at 10.5 months also had the highest average margin above cost in the 5-year plan. The 10.5 month system also showed the highest present value compared to the other slaughter age systems. However, the 10.5 month system had 7 production cycles, 3 less than the 8.5 month system. The income from the first production year of the 10.5 month group was not enough to contribute towards fixed costs.
Table 4.2 Variables influencing the margin above cost during the different slaughter age systems.

<table>
<thead>
<tr>
<th>Slaughter age (Months)</th>
<th>Income (R)</th>
<th>Increase/Decrease (%)</th>
<th>Feed Costs (R)</th>
<th>Increase (%)</th>
<th>Total Cost (R)</th>
<th>Increase (%)</th>
<th>Gross margin (R)</th>
<th>Increase/Decrease (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5</td>
<td>1,413.88</td>
<td></td>
<td>309.78</td>
<td></td>
<td>1,215.58</td>
<td></td>
<td>198.30</td>
<td></td>
</tr>
<tr>
<td>10.5</td>
<td>1,788.11</td>
<td>26</td>
<td>469.04</td>
<td>51</td>
<td>1,454.31</td>
<td>20</td>
<td>333.79</td>
<td>68</td>
</tr>
<tr>
<td>12.5</td>
<td>1,864.78</td>
<td>4</td>
<td>647.20</td>
<td>38</td>
<td>1,706.04</td>
<td>17</td>
<td>158.73</td>
<td>-52</td>
</tr>
<tr>
<td>14.5</td>
<td>2,070.86</td>
<td>11</td>
<td>844.24</td>
<td>30</td>
<td>1,191.78</td>
<td>13</td>
<td>149.08</td>
<td>-6</td>
</tr>
<tr>
<td>16.5</td>
<td>2,064.09</td>
<td>-0.3</td>
<td>1,060.18</td>
<td>26</td>
<td>2,156.40</td>
<td>12</td>
<td>-92.31</td>
<td>-162</td>
</tr>
</tbody>
</table>

Figure 4.1 Graphical illustration of gross margin for the different slaughter age systems.

Although total income increased by 4 % from 10.5 to 12.5 month slaughter regimes, feed costs were 38 % higher. This resulted in 17 % more total costs and subsequently a 52 % decrease in the margin above costs. It can be see from Table 4.1 that disease and parasites control increased by 3 % between 10.5 and 12.5 months slaughtering. Due to the high number of 3rd and 4th grade skins that were reported for birds slaughtered at 12.5 months in this study, meat contributed a higher income (50 %) than leather (47 %). These findings support the findings of Meyer (2003), who reported that the occurrence of skin damage was prevalent amongst older birds due to aggressive behaviour. Income from feathers contributed 3 % of the total income at 12.5 months. As seen in Table 4.3, the sensitivity analysis for birds slaughtered at 12.5 months reveals that a 7 % reduction of income (cost unchanged) and a 7 % increase of costs (income unchanged) still produced a positive margin. The
sensitivity analysis also shows that the 12.5 month slaughter system was only profitable when combined risk effects of a simultaneous increase in costs and decrease in income (2.5 %) were considered. The present value decreased by 227 % between the 10.5 month slaughter group and the 12.5 month group. Furthermore, both the average income and costs were lowest at 12.5 months. This is caused by the annual reproduction cycle of ostriches, which renders chicks unavailable for a specific period in the cycle during specific months.

The income contribution for the three different products at 14.5 months occurred in a ratio of 44 %: 51 %: 5 % for skin, meat and feathers. Total income increased by 11 % for the 14.5 month group as opposed to the 12.5 month group. However, feed costs increased by 30 % from 12.5 to 14.5 month slaughtering. The margin above cost decreased by 6 % and the present value decreased by 18 % for the 14.5 month group compared to the 12.5 month slaughter group. The reduction of margin above cost might have been influenced by the increase of poor skin grades at 14.5 months. The production cycles were five each at 12.5 months and 14.5 months respectively. The sensitivity analysis reveals that a 7 % increase of costs (income unchanged) produced a positive margin. It also shows that the 14.5 months slaughter system was only profitable when combined risk effects of a simultaneous increase in cost and decrease in income of 2.5 % were considered. A decrease of 0.3 % in total income was observed for birds slaughtered at 16.5 months. As a result, there was a negative margin above cost (R-91.31) for the 16.5 month slaughter group, as well as an expected negative present value.
Table 4.3 Price risk sensitivity analysis for different slaughter age systems

<table>
<thead>
<tr>
<th>Slaughter age (months)</th>
<th>Risks</th>
<th>Margin above cost per bird for different rates of change in income and cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0%</td>
</tr>
<tr>
<td>8.5</td>
<td>A</td>
<td>198.30</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>198.30</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>198.30</td>
</tr>
<tr>
<td>10.5</td>
<td>A</td>
<td>333.79</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>333.79</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>333.79</td>
</tr>
<tr>
<td>12.5</td>
<td>A</td>
<td>158.73</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>158.73</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>158.73</td>
</tr>
<tr>
<td>14.5</td>
<td>A</td>
<td>149.08</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>149.08</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>149.08</td>
</tr>
<tr>
<td>16.5</td>
<td>A</td>
<td>-92.31</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>-92.31</td>
</tr>
</tbody>
</table>

Notes:
A. Scenario where income decreases and costs remain unchanged.
B. Scenario where costs increase and income remains unchanged.
C. Scenario where combined effects of decreased income and increased costs happens simultaneously.
Table 4.4 Annual income, cost and present value of margin above cost per bird for each slaughter age over a 5-year planning horizon

<table>
<thead>
<tr>
<th>Slaughter age (months)</th>
<th>Item</th>
<th>Rand per year</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Total R</th>
<th>Average R</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Year 1</td>
<td>Year 2 *</td>
<td>Year 3 *</td>
<td>Year 4 *</td>
<td>Year 5 *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.5</td>
<td>Income</td>
<td>2827.76</td>
<td>2874.93</td>
<td>2922.88</td>
<td>2971.62</td>
<td>3021.19</td>
<td>14618.38</td>
<td>2923.68</td>
</tr>
<tr>
<td></td>
<td>Cost</td>
<td>2431.16</td>
<td>2512.65</td>
<td>2596.87</td>
<td>2683.92</td>
<td>2773.88</td>
<td>12998.47</td>
<td>2599.69</td>
</tr>
<tr>
<td></td>
<td>Margin above cost</td>
<td>396.61</td>
<td>362.28</td>
<td>326.01</td>
<td>287.71</td>
<td>247.31</td>
<td>1619.91</td>
<td>323.98</td>
</tr>
<tr>
<td>10 Production cycles</td>
<td>PV of Margin †</td>
<td>357.31</td>
<td>294.03</td>
<td>238.37</td>
<td>189.52</td>
<td>146.76</td>
<td>1226.00</td>
<td></td>
</tr>
<tr>
<td>10.5</td>
<td>Income</td>
<td>1788.11</td>
<td>3635.85</td>
<td>1848.25</td>
<td>3758.15</td>
<td>2955.39</td>
<td>13985.74</td>
<td>2797.15</td>
</tr>
<tr>
<td></td>
<td>Cost</td>
<td>2591.30</td>
<td>1831.03</td>
<td>2767.93</td>
<td>1955.84</td>
<td>2965.60</td>
<td>12102.69</td>
<td>2420.54</td>
</tr>
<tr>
<td></td>
<td>Margin above cost</td>
<td>-803.19</td>
<td>1804.82</td>
<td>-919.68</td>
<td>1802.31</td>
<td>-1.21</td>
<td>1883.05</td>
<td>376.61</td>
</tr>
<tr>
<td>7 Production cycles</td>
<td>PV of Margin †</td>
<td>-723.60</td>
<td>1464.84</td>
<td>-672.46</td>
<td>1187.23</td>
<td>68.78</td>
<td>1324.79</td>
<td></td>
</tr>
<tr>
<td>12.5</td>
<td>Income</td>
<td>1864.78</td>
<td>1895.88</td>
<td>1927.50</td>
<td>1959.65</td>
<td>1992.33</td>
<td>9640.13</td>
<td>1928.03</td>
</tr>
<tr>
<td></td>
<td>Cost</td>
<td>1706.04</td>
<td>1763.23</td>
<td>1822.33</td>
<td>1883.42</td>
<td>1946.55</td>
<td>9121.57</td>
<td>1824.31</td>
</tr>
<tr>
<td></td>
<td>Margin above cost</td>
<td>158.73</td>
<td>132.65</td>
<td>105.17</td>
<td>76.23</td>
<td>45.78</td>
<td>518.56</td>
<td>103.71</td>
</tr>
<tr>
<td>5 Production cycles</td>
<td>PV of Margin †</td>
<td>143.00</td>
<td>107.66</td>
<td>76.90</td>
<td>50.21</td>
<td>27.17</td>
<td>404.95</td>
<td></td>
</tr>
<tr>
<td>14.5</td>
<td>Income</td>
<td>2070.86</td>
<td>2105.40</td>
<td>2140.51</td>
<td>2176.21</td>
<td>2212.51</td>
<td>10705.50</td>
<td>2141.10</td>
</tr>
<tr>
<td></td>
<td>Cost</td>
<td>1921.78</td>
<td>1986.19</td>
<td>2052.77</td>
<td>2121.38</td>
<td>2192.69</td>
<td>10275.01</td>
<td>2055.00</td>
</tr>
<tr>
<td></td>
<td>Margin above cost</td>
<td>149.08</td>
<td>119.21</td>
<td>87.74</td>
<td>54.64</td>
<td>19.82</td>
<td>430.49</td>
<td>86.10</td>
</tr>
<tr>
<td>5 Production cycles</td>
<td>PV of Margin †</td>
<td>134.31</td>
<td>96.75</td>
<td>64.16</td>
<td>35.99</td>
<td>11.76</td>
<td>342.97</td>
<td></td>
</tr>
<tr>
<td>16.5</td>
<td>Income</td>
<td>0.00</td>
<td>2098.52</td>
<td>2133.52</td>
<td>2169.10</td>
<td>3470.93</td>
<td>9872.07</td>
<td>1974.41</td>
</tr>
<tr>
<td></td>
<td>Cost</td>
<td>1908.37</td>
<td>2113.12</td>
<td>2178.10</td>
<td>2253.44</td>
<td>2218.08</td>
<td>10671.12</td>
<td>2134.22</td>
</tr>
<tr>
<td></td>
<td>Margin above cost</td>
<td>-1908.37</td>
<td>-14.60</td>
<td>-44.58</td>
<td>-84.34</td>
<td>1252.85</td>
<td>-799.05</td>
<td>-159.81</td>
</tr>
<tr>
<td>4 Production cycles</td>
<td>PV of Margin †</td>
<td>-1719.26</td>
<td>-11.85</td>
<td>-32.60</td>
<td>-55.56</td>
<td>743.51</td>
<td>-1075.76</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
* Income had an annual increase of 1.67 %
π A salvage value based on the price of a live bird was used to determine part of the income
# Costs had an annual increase of 3.55 %
† Discount rate was based on the current bank lending rate of 11 %
The economic viability of an intensive ostrich production system is dependent on skin, meat and feathers as identified in this study. It is evident that profitability is higher when the contribution from the skin is proportionately higher in relation to the other end-products. Although the amount of feathers produced contributed to the income generated from the different slaughter ages; skin size, skin quality and carcass weight contributed a significantly greater percentage towards income generated from slaughter birds. It is also clear that the ostrich industry will be unprofitable if birds are raised mainly for meat production. Income increased with slaughter age but direct costs affected the margins of the older slaughter age groups. Feed costs and health control costs increased directly in relation to an increase in slaughter age. Feed costs contributed an average of 63% of total costs less the cost of 4 month-old ostrich chicks for the five different slaughter ages. These results
support previous studies which report that feed costs constitute 75 – 80 % of the total costs of an ostrich production unit. However, the cost of feeds for chicks of one day to 4 month old, were not determined in this study. The results presented in this study clearly show that there is a direct correlation between profitability and slaughter age. Slaughtering at 10.5 months is the most economic alternative and it demonstrates a higher present value in terms of the 5-year project planning horizon. However, the 8.5 month slaughter had the most production cycles over the 5-year period. This is important as the income derived from the first production year contributes towards financing the fixed costs of the enterprise. The 10.5 month slaughter regime is more profitable than any other age group when considering the sensitivity of an intensive ostrich production system to potential income and cost changes. Although, 8.5 and 10.5 month slaughtering revealed the most profitability, certain changes in the management and handling of birds in older age groups may improve profitability in older age groups. This warrants further research on the management and handling of older birds.

4.7 REFERENCES


CHAPTER 5

GENERAL CONCLUSION AND FUTURE PROSPECTS

5.1 INTRODUCTION

At present the relative economic contribution of the three main ostrich end-products occurs in a ratio of 50: 45: 5 for leather: meat: feathers respectively. Intensive production of slaughter ostriches can be a successful enterprise, provided the required competence, care and commitment are in place and correct feeding strategies and sound management practices are applied. There are many factors that influence the profitability of an intensive ostrich production system. The age of the bird, nutrition and management all influence the quality of the leather. The objective of this study was to investigate the effect of the slaughter age on production parameters in order to establish the economic viability of slaughter ostriches under an intensive production system. The outcome will contribute to scientific information, specifically on the production and profitability of ostriches slaughtered at the ages of 8.5, 10.5, 12.5, 14.5, and 16.5 months. The thesis has achieved these objectives. The results are synthesized below and the shortcomings of the research as well as its applicability to management are pointed out.

5.2 ANSWERS TO MAJOR QUESTIONS POSED IN THIS THESIS

This study proves that feed intake increases with age. The increase is largely attributable to the increase in nutrients required to sustain levels of production and body maintenance. Feed intake is clearly a function of age and weight as birds were fed similar diets throughout the research trials. Furthermore, feed intake is not influenced by gender in ostriches between 8.5 and 16.5 months of age. There were significant differences in slaughter weight between the birds slaughtered at 8.5, 10.5 and 12.5 months of age respectively, with 8.5 months recording the lowest slaughter mass. The birds slaughtered at 14.5 and 16.5 months were heavier than the other age groups but not significantly different from each other. Although males weighed, on average, 1.3 kg more than females at slaughter, no significant differences in slaughter weight were found between males and females.
Birds slaughtered at 8.5 months had lower cold carcass mass compared to birds slaughtered at subsequent slaughter ages. No differences were recorded between birds slaughtered at 10.5 and 12.5 months of age, but they were significantly different when compared to other age groups. A similar trend was observed between birds slaughtered at 14.5 months and 16.5 months of age, where they did not differ from each other in cold carcass weight, but did differ significantly from the other slaughter ages. The average cold carcass weight did however differ significantly between male and female birds at the end of the trial. This result was unexpected, as slaughter weight did not differ significantly between male and female birds.

Birds slaughtered at 8.5 months of age had smaller skin surface area compared to those at subsequent slaughter ages. Birds slaughtered at 10.5 and 12.5 months of age did not differ significantly from each other. Similarly, skin surface area did not differ between birds slaughtered at 14.5 and 16.5 months of age but was significantly larger than those of 8.5, 10.5 and 12.5 months of age. Furthermore, the percentage of 1st grade skins decreased as birds were slaughtered at older ages and the percentage of lower grade skins (3rd to 5th grade) increased with slaughter age. Gender did not influence the mean skin surface area or the grading in this trial.

Feather production was fairly low at 8.5 months followed by an increase at 12.5 months where it appeared to stabilize between 12.5 and 14.5 months of age, followed by a slight decline at 16.5 months of age. The mean weight for total feathers produced was significantly higher for male birds than female birds.

The economics of slaughter ostrich production is influenced by the slaughter age of the birds. The income contribution of the three main end-products towards the margin above cost differs with slaughter age. The study indicated that the slaughter ages with the highest margin above cost were those that reported the highest proportional income from the skin relative to the other two end-products. This result was expected, as skin is still the main end-product of slaughter ostriches. The income from skin, however, decreases with slaughter age, and this is ascribed to poorer grading for older birds due to skin damage. It is also clear that the ostrich industry is non-viable as a single product enterprise, due to the fact that the three main products compliment each other. In terms of costs, both feed and health costs increase
with slaughter age. It is therefore to be expected that 16.5 month slaughtering will not be profitable because of the increased costs.

5.3 RECOMMENDATIONS

5.3.1 Economic considerations

Selection should take into account economic considerations like skin surface area, skin quality and carcass weight. Both leather and meat contribute significantly more than feathers to the income generated from ostrich farming. Selection for economic considerations should be based on these two main products. This study has shown that the 10.5 month slaughtering regime offers the most profitable slaughter age, in terms of margin above cost. Furthermore, when comparing the different slaughter ages with each other over a 5-year planning horizon, the present value of margin above cost for the 10.5 month slaughter regime still reveals the highest present value. Slaughtering at higher ages reveals sensitivity to gross margin in relation to price risks. Therefore, slaughtering at 10.5 months should be considered as it proves to be the most profitable slaughter age.

5.3.2 Further research

This study was carried out in line with general management practices used in an intensive ostrich industry. However, further research is needed to evaluate and compare the economic viability of different slaughter ages under improved management practices, for example, those documented by Meyer (2003). There is a need to investigate profitability of increased live weight at earlier slaughter ages by identification of superior genetics which might lead to successful genetic improvement programmes. Research is also needed to determine the influence of different feeding strategies and nutrient composition on the yield and profitability of different slaughter age systems. A different ideal slaughter age may be applicable in cases where ostriches are raised on pastures, for example in the Southern Cape. (Brand, 2006) suggest that it may be relatively cheaper to raise birds on pastures and therefore may result in a different ideal slaughter age. This needs to be studied in future.
5.4 ACHIEVEMENTS OF THIS RESEARCH STUDY

As indicated above, the research study has achieved all its objectives. It has proved that slaughtering earlier than 14 months of age can minimize both feed costs and the risk of damage to the skin which accompanies older birds. It has thereby confirmed earlier studies by Cloete, Van Schalkwyk & Pfister (1998) and Meyer (2003).

The major contribution of this research is that it adds to established baseline data and methodologies which determine the economic viability of slaughtering at different ages. Thus the data may be used to inform managerial decision-making as well as assist further studies in the ostrich industry.

5.5 REFERENCES

