EFFICIENCY OF BROILER PRODUCTION: A CASE STUDY OF TWO COMMERCIAL ENTERPRISES AROUND GABORONE (BOTSWANA)

by

Gertrude Nurse Kelebemang
BSc. (Agric.), University of Botswana

Assignment presented in partial fulfillment
of the requirements for the Degree

MASTER OF PHILOSOPHY IN LIVESTOCK INDUSTRY MANAGEMENT (POULTRY SCIENCE)

Pectora roborant cultus recti

in the

Division of Distance Education, Department of Animal Sciences
Faculty of Agriculture, Forestry and Sciences
UNIVERSITY OF STELLENBOSCH

Supervisor: Dr. M. Ciacciariello

December 2005

http://scholar.sun.ac.za/

DECLARATION:

I, the undersigned, hereby declare that the work contained in this assignment is my own original work and has not previously in its entirely or in part been submitted at any university for a degree.

Signature: Date: 31 October 2005

http://scholar.sun.ac.za/

ABSTRACT

The study investigated the performance of broiler production in two enterprises around Gaborone. The main emphasis was on performance and feed efficiency of four major production parameters, which include feed intake (FI), age at slaughter, body weight (BW) and feed conversion ratio (FCR). The averages for slaughter age, BW (live weight), FI and FCR for the two enterprises combined were 39.6 days, 1.8 kg, 3.41 kg/bird and 1.96, respectively. For the entire rearing period the average performance efficiency factor for the two enterprises was 224.

The results of the current study showed that age at slaughter, BW, cumulative FI, FCR and mortality in the two farms declined significantly (P<0.001) over time. These improvements in performance may be ascribable to the genetic improvements of the broiler bird for fast growth, improved nutritional status as well as efficiency in management on the part of producers.

OPSOMMING

Die studie ondersoek die vordering van braaikuiken produksie in twee ondernemings in die omgewing van Gabarone. Die klem was op die prestasie en voer doeltreffendheid van vier groot produksie parameters. Die parameters sluit in; voerinname (VI), ouderdom by slag, liggaamsmassa (LM), en voeromsettings verhouding (VOV). Die gekombineerde gemiddeldes vir die twee ondernemings vir slagouderdom, LM (lewende massa), VI en VOV was onderskeidelik 39.6 dae, 1.8 kg, 3.41 kg/voël en 1.96. Die gemiddelde prestasie doeltreffendheidsfaktor vir die twee ondernemings, vir die hele groei periode, was 224.

Die resultate van die studie het daarop gedui dat ouderdom by slag, LM, kumulatiewe VI, VOV en mortaliteite aansienlik afgeneem (P<0.001) het oor tyd. Hierdie verbeteringe in vordering kan toegeskryf word aan die genetiese verbeteringe van die braaikuiken voël vir vinnige groei, verbeterde voedingstatus, sowel as doeltreffendheid in bestuur vanaf die produseerders.

http://scholar.sun.ac.za/

ACKNOWLEDGEMENTS

I would like to express my sincere thanks to the following people for their contribution to this thesis:

Dr. Mariana Ciacciariello for her guidance, supervision and support she provided for the success of this research. I would not imagine it an easy work without her assistance. I am indebted to her for her tireless efforts in helping me see this thesis through to completion.

Dr. Boingotlo Sebolai for the assistance with the statistical analysis.

Mr. Metseyabagale Kolanyane for the invaluable contribution of his knowledge in research and for his continued interest and encouragement in my progress throughout the course of writing this thesis.

Farms A and B for allowing me to use their production record sheets, without their support, it was not going to be easy to collect the data required for this study.

Dr. John Moreki who introduced and encouraged me to enrol with the University of Stellenbosch for the MPhil degree programme. To him I say "thank you very much and may the Lord bless you"

.

Dr. Farai Nyabadaza for editing and proof reading of the document.

To my family, thank you all for your generous love, support, interest and encouragement throughout the course of my studies. Finally, I thank Almighty God for His love, guidance and protection throughout my studies.

http://scholar.sun.ac.za/

ACKNOWLEDGEMENTS

I would like to express my sincere thanks to the following people for their contribution to this thesis:

Dr. Mariana Ciacciariello for her guidance, supervision and support she provided for the success of this research. I would not imagine it an easy work without her assistance. I am indebted to her for her tireless efforts in helping me see this thesis through to completion.

Dr. Boingotlo Sebolai for the assistance with the statistical analysis.

Mr. Metseyabagale Kolanyane for the invaluable contribution of his knowledge in research and for his continued interest and encouragement in my progress throughout the course of writing this thesis.

Farms A and B for allowing me to use their production record sheets, without their support, it was not going to be easy to collect the data required for this study.

Dr. John Moreki who introduced and encouraged me to enrol with the University of Stellenbosch for the MPhil degree programme. To him I say "thank you very much and may the Lord bless you".

To my family, thank you all for your generous love, support, interest and encouragement throughout the course of my studies. Finally, I thank Almighty God for His love, guidance and protection throughout my studies.

http://scholar.sun.ac.za/

TABLE OF CONTENTS

http://scholar.sun.ac.za/

LIST OF TABLES

http://scholar.sun.ac.za/

LIST OF FIGURES

http://scholar.sun.ac.za/

LIST OF ACRONYMS AND ABBREVIATIONS

BW	Body weight
BWG	Body weight gain
FCR	Feed Conversion Ratio
FI	Feed intake
g	gram
GLM	General linear models
IBD	Infectious bursal disease
kg	kilogram
km	kilometre
LSD	Least square difference
M^2	metre squared
ME	Metabolisable energy
MJ	Megajoule
NCD	Newcastle disease
PEF	Performance efficiency factor
vs.	*versus*

http://scholar.sun.ac.za/

CHAPTER 1
GENERAL INTRODUCTION

Commercial broiler production in Botswana is relatively young, and it could be considered a developing industry when compared with that of neighbouring countries. Prior to the beginning as an organised industry, Botswana only used indigenous birds as a source of chicken meat (Moreki, 1997).

Broiler production has become an important industry in that it provides job opportunities, generate income and it is a good source of protein for human consumption (Mosinyi, 1996). However, the rapid growth this industry has attained has been hampered by numerous production constraints mostly relating to the different input required for production. Due to the inability to produce and commercialise many of these production inputs, (*i.e.* feed, equipment and production of day old chickens) the local industry has heavily depended on imports from neighbouring countries such as the Republic of South Africa and Zimbabwe (Ministry of Agriculture, 2000) resulting in increased feed prices.

Some research has been conducted on broiler production in Botswana, especially on small-scale enterprises; to address the current needs of this growing industry, there is need to undertake research pertaining to this subject. This study attempts to investigate the evolution of the industry, as well as factors of efficiency strategies used in assessing efficiency of the current broiler production system.

Preliminary investigation indicated that variable efficiency factors such as mortality, feed conversion ratios (FCR), age at slaughter and average weight influenced production but there was no documented information on significance of the contribution of the production parameters to production. A secondary objective will be to investigate how these factors influence broiler efficiency and how they vary between the two farms.

http://scholar.sun.ac.za/

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Commercial hybrids of broiler chickens are widely spread worldwide, especially for their nutritious meat as a source of protein. However, with the changes occurring in the primary breeding scene over the past 15 years, most of the broiler production in the world is conducted using birds that have been highly selected for growth and feed efficiency characteristics (Settar *et al.*, 1999). In developing countries such as Botswana where these genotypes were not available, most poultry production happened in domestic households and small-scale farms using indigenous genotypes that were not selected for meat production. The advantage of commercial hybrids broilers as compared to local chickens is that, their production cycle is significantly shorter than what used to be; only 39 days are needed to achieve a weight of 1.70 kg as opposed to 5 to 6 months for local breeds (Dozier *et al.,* 2001).

There are different methods of measuring the efficiency of broiler production. The aim of this chapter is to revise the literature in order to gather an understanding of how this could be done more efficiently. This in turn, will allow making a better assessment of the development of the broiler industry that is being evaluated.

2.2 Measuring Efficiency of Production

According to Hall (2002), efficiency is a measure of how well broilers perform in terms of converting the feed they eat into meat. Efficiency gives indices of how closely a ration meets a broiler's specific nutrient requirements and of the relative demands of maintenance. Hall (2002) suggested that together with growth rate, days to market and mortality, feed efficiency has been considered as one of the important parameters in assessing the potential of the bird's feeding programme. Previously, Leeson *et al.* (1996) suggested new measures of feed efficiency in broiler production and factors relating to their use. These include energy intake to weight gain ratio, which the researchers ascribed to as energy intake being a function of weight gain and that, it is the energy value of feed fed to the birds that has to determine the weight gain. Therefore, it is of utmost

http://scholar.sun.ac.za/

importance to feed birds with high-energy value feed so as to maximise their performance. Feeding programmes may also affect the weight gain of a bird.

Leeson (2004) states that feed efficiency has been one of the major criteria used in defining the performance of broiler chickens since the start of the modern broiler industry. This parameter is affected by bird age, sex, health and environmental temperature even though the major factor is usually the diet's energy concentration (Leeson *et al.,* 2000). The researcher states that the lowest feed efficiency might always be the most profitable because economics can dictate the optimum use of lower cost feed rather than expensive ones. In North America, feed efficiency is described as the ratio of feed intake to weight gain, while in Europe it is described as the ratio of weight gain to feed intake. Kleyn (2003) indicated that as feed comprises the major input costs in broiler production, the nutritionist and the diet formulated have a major impact on the ultimate profitability of any broiler operation. Effective broiler production can only be achieved through accurate measurement of the production cycle and correct record keeping in poultry operations However, in an integrated broiler operation it may be difficult to assess the effect of the impact of many production inputs in an effective manner; as it will be impossible to link the final level of input thus becoming difficult to develop the true optimal production solution (Emmerson, 2000).

Kleyn (2003) indicated that the ideal model to measure broiler production may be difficult to achieve, however several South African companies have measured performance characteristics very successfully. In the United States, broiler integrators also measured performance characteristics where they moved to cost driven analysis of results. It has been suggested that in the future, all broiler production would have to measure performance in terms of returns rather than costs (Emmerson, 2000). Conversely, Leeson (2000) has studied measurements of efficiency in broiler production, and indicated that, since the start of the modern broiler industry, feed efficiency has been one of the major criteria used in defining the performance of broiler chickens. Feed cost per kilogram (kg) of live weight is also regularly used to measure the efficiency of broiler operations (Leeson, 2000). The researcher has shown that over the years there has been a

http://scholar.sun.ac.za/

steady decline in feed efficiency from 2.2 kg in the early 1960's to 1.75 kg under certain situations due to genetic selections. Regardless of the system used, the purpose is to obtain a measure of how efficiently the feed is being utilised by the bird, which is obviously of economic importance because feed represents about 70% of the total costs of production (Teguia & Beynen, 2004).

Despite the fact that evaluating broiler performance is complex, some equations have been developed in order to achieve a good idea of the efficiency of the production system in question. Starting from simple measurement of bird weight, to age at slaughter, mortality and FCR, the industry has moved to more complex equations such as the performance efficiency factor (PEF). The advantage of using PEF, which is calculated as: Liveability% x mass (kg) x 100/ FCR x age in days; is that, bird weight, age at slaughter, mortality and FCR are considered simultaneously for a reasonable purpose of technical efficiency of broiler performance (Kleyn, 2003).

Feed efficiency is, therefore a useful measure of performance as long as all other factors affecting both growth and feed intake are either minor or do not vary from flock to flock (Leeson, 2000). Factors such as growth rate, days to market, mortality and feed efficiency have been considered as one of the important parameters in assessing the potential of bird strain on feeding programme. Different nutrients could also be considered when evaluating cost effectiveness of a poultry operation. For example, the level of production will depend greatly in the amount of nutrients absorbed by the bird. This in turn depends on the dietary energy level, which will determine greatly what will be the intake per bird of a particular feed. Leeson (2000) suggested that the broiler eats to its maximum physical capacity; therefore varying the energy density of the diet can easily control the birds' energy intake. However, as the birds get older, they seem to adjust their intake in relation to the diet's energy level so as to normalise their energy intake. According to Kleyn (2003), what is needed for an efficient production is a system that takes all of the broiler performance parameters used in the calculating PEF together with some financial information. Such a system must take the major production costs into consideration. In the opinion of Emmert (2000), the principle that is of particular concern is that where

http://scholar.sun.ac.za/

capacity is not limited, then the objective should be to maximise the return per unit of production per bird. The researcher suggested that where capacity is limited, the objective must be to maximise the return per unit time.

Feed is used by the bird for two basic reasons: namely for growth and for maintenance. But in young birds most of the feed is used for growth, and very little is used for maintenance hence a very good efficiency (Leeson, 2004). As the birds age, the feed efficiency deteriorates because the broiler ever increasing body mass (Leeson *et al.,* 1996). However, with continuously changing genotypes, the efficiency in broiler production is continuously improving and more feed is directed towards growth and less for maintenance as days to market decline (May *et al.,* 1998).

Groen *et al.* (1998) contended that broiler production is a system with several factors, namely multiplier breeders, commercial growers and processors, but in Botswana only commercial broiler production is practised. Farooq *et al.* (2000, 2001) developed a model to analyse profits of multiplier breeders and commercial growers using a function of several performance traits of parent flocks and the final products. Kitsopanidis & Manos (1991) described net profit per unit weight of broiler meat as a function of market age. The factors that are commonly used in Botswana are the net profit per bird *vs.* production costs.

Broiler standards vary considerably, depending on the genetics, management practices, feeding programme, health status, and climatic conditions, among other factors (May *et al.,* 1998). Table 2.1 shows the growth performance of broiler chickens at 40 days of age. Modern broilers have changed dramatically over the last couple of decades (Groen *et al.,* 1998). They are genetically selected to gain weight at such unnaturally rapid rates, for profitability and meeting the ever increasing market demand. With good bio-security programmes, optimum management and housing, and adequate nutrition, it is quite common for broilers to achieve approximately 1.5 to 1.8 kg at 35 days of age. Modern broilers are gaining an average of 50 g per day under current field conditions. However, Groen *et al.* (1998) estimated that the same birds have the genetic capability to double

http://scholar.sun.ac.za/

this rate of gain. This however may be difficult to achieve. This would mean a corresponding reduction in the slaughter age, and due to the fact that exaggerated growth rate in chickens can cause heart failure and gait alteration causing leg and joint problems. Such weight gains would be disastrous. However, a high rate of weight gain would be possible when all factors needed for broiler growth are provided, such as optimum management, superior health, excellent environmental conditions, and most important of all, an understanding of the nutritional requirements of the changing broiler. Table 2.1 shows the growth performance of broiler chickens at 40 days of age.

Table 2.1 The average broiler performance over a 40 day period

Parameter	**Expected performance**
Body weight (one-day-old) (g)	45 g
Body weight at 7 days (g)	One day of age weight x 4
First week % mortality	< 0.7%
Average daily weight gain (g))	50 g
Feed conversion ratio	1.85
% Total mortality	<4%

Source: Leeson (2000)

According to Lacy & Vest (2002), the first requirement for growing broilers is adequate housing. Since broiler production is essentially a chick brooding operation, the house should contain equipment so that such factors as temperature, moisture, air quality and light can be controlled easily. The housing should also provide for efficient installation and operation of brooding, feeding, watering and other equipment. Bains (1992) emphasised that broiler house designs should be dictated by the geographical locations, but due to the unpredictability of the weather, the geographical locations have not been helpful. A previous study of Moreki (1997) showed that in Botswana, most broiler houses are open-sided, suggesting that temperature is not controlled, as most chicken houses are not insulated. In Botswana most chicken houses have concrete floors and walls and are roofed with corrugated iron sheets. During extreme temperatures, cold water is sometimes sprinkled over the roofs as a method of cooling. Painting roofs white is one

http://scholar.sun.ac.za/

way of reflective insulation in some poultry enterprises in Botswana. With regard to the placement of birds, i.e. birds/m^2 floor space, it is most important to adhere to the standard requirements of stocking rates. Overstocking will result in poor performance of birds, as birds will not have enough space to eat and exercise. Limited drinking space and inappropriate feeding space will also have a negative impact on the performance of the birds. It is therefore advisable to optimise the use of the floor space accordingly.

Due to the high impact of feeding costs on the efficiency of broiler operation and production costs, the factors related to the feed and feeding systems that will impact the profit of the production system will be discussed in Section 2.3.

2.3 Types of Broiler Ration

Broiler feeds are referred to as complete feeds since they are designed to contain all essential amino acids, energy, vitamins, minerals and other necessary nutrients for proper growth and health of the bird (Lacy & Vest, 2002). Broilers have larger bodies and gain weight more rapidly and therefore are fed diets with high protein energy level. Hall (2002) states that broilers are fed different types of rations during the course of rearing, as the purpose of phase feeding is to meet the changing requirements of the birds, which happen as they grow. Lacy & Vest (2002) stated that where feed is changed twice, the feeding process is known as two-phase feeding while the three-phase feeding contains three rations. The feeding programme in Botswana is that of four phases: such as broiler starter, broiler grower and finisher and post finisher (Mosinyi, 2000).

According to Leeson *et al.* (1996), high energy level feeds cost much more than low energy feeds and that there is a price to pay for improved feed efficiency brought about by high fat diets. These researchers mentioned that the energy of the diet has no effect on growth rate but that it will affect the feed intake of the bird. Feed to gain ratio therefore improves as diet's energy level increases. A consideration of the ration of energy intake to carcase weight shows that if the energy intake is low it will give a low carcase weight and this will impact negatively on the value of a bird.

http://scholar.sun.ac.za/

According to May *et al.* (1998), the broilers' maintenance energy needs are greatly influenced by the temperature of its environment. Sandercock *et al.* (1995) suggested that after initial brooding, the bird must use some of the feed to maintain body temperature. Under ideal conditions of around 20-30^{o} C, the bird uses a minimum of feed to maintain body temperature. In cooler conditions, more dietary energy must be used to maintain body heat, and so less feed is used for growth and consequently feed efficiency will deteriorate and feed intake will increase by about 1% for each 1^{o} C below 20^{o} C (Sandercock *et al.*, 1995).

2.4 Poultry Production in Botswana

In Botswana as in many developing countries, small-scale poultry producers as well as the indigenous (local) chicken producers constitute the majority (Moreki, 1997). These enterprises are found mostly in rural villages where production inputs are difficult to obtain and marketing outlets are not well organised. In contrast, large-scale enterprises are concentrated along the railway line, and near urban areas (especially big towns) where they have access to production facilities and marketing outlets (Pule, 1977).

The broiler production systems in Botswana are of commercialisation purposes. However, the vast majority of poultry is produced in small-scale farms with intensive backyard units. These intensive units maintain the birds indoors, preventing outdoor movements and minimising the adverse effects of direct sunlight and potential environmental elements (Moreki, 1997). These types of systems, where birds are confined and cannot gather their own feed calls for the use of balanced rations that are expensive (Oluyemi & Roberts, 1979). Birds are housed at a certain stocking density that is highly dependent on the management and financial decisions of each particular farm or integration. In all cases, the construction of a new broiler facility for intensive rearing requires a high initial capital investment in order to cover the costs of new broiler houses and equipment, such as feeders and drinking systems. Part of the costs involved in this type of systems includes highly skilled manpower and adherence to disease prevention and that control schedules should be included into the final costs of the operation (Leeson *et al.,* 1996).

http://scholar.sun.ac.za/

Literature on Botswana poultry population is conflicting and inconsistent. For instance, Central Statistics Offices (2004) estimated village flocks to be 22 300 while the Ministry of Agriculture (2000) estimated it to be 300 000. Commercial broilers are estimated to be over 30 million (Poultry Annual report, 2004).

2.5 Main Poultry Production Systems

The main poultry production systems can be broadly classified into: backyard scavenging systems, small-scale commercial systems and large-scale commercial systems. These categories will be described in the sections below.

2.5.1 Backyard (village) scavenging systems

This is basically an extensive production system. It is an old system based on small flocks in backyard and of minimum production inputs. The birds are mainly of local, native type (indigenous) that roam the farms or village freely in search of feed. These birds are occasionally provided with home grown grains. They usually have minimum shelter. This system of production exists in most developing countries and could account for up to 50 to 80% of the total eggs (Reddy, 1991). The amount of meat and eggs produced by scavenging chickens is not known in Botswana. However, due to the growth characteristics of these birds, it could only account for house-hold consumption, not making the base for commercial production.

2.5.2 Small-scale commercial systems

Reddy (1991) suggested that the small-scale commercial systems vary in size from 1000 to 10 000 birds (layers and/or broilers). In Botswana, small-scale commercial enterprises are those with up to 200 layers and/or that sells or slaughter not more than 5 000 broilers per cycle (Mosinyi, 1996). Exotic strains of birds are kept and a deep litter system is usually used. There are no local birds kept under commercial systems. The characteristic feature of these systems is intensive housing and permanent structures that are roofed with thatch or asbestos or corrugated iron sheets. Birds are fed *ad libitum* and mostly on a

UNIVERSITEIT STELLENBOSCH
BIBLIOTEEK

http://scholar.sun.ac.za/

two phase feeding programme. The feed types are of broiler starter and broiler finisher mash for broiler birds and layers mash for layers respectively.

2.5.3 Large-scale commercial systems

This is a completely intensive system of poultry production. While more than 90% of chicken meat comes from large-scale commercial farms in the developed and industrialised countries, the figure is less than 50% in developing countries (Reddy, 1991). In intensive systems, birds are reared at high densities and flocks are kept under the same environment and management practices (Silverside & Jones, 1992). In Botswana, 90% of chicken meat comes from the large-scale enterprises.

2.5.4 Development of the broiler industry in Botswana

The broiler industry has grown rapidly to the extent that every household in the country has access to chicken meat (Moreki, 1997). Data on chicken meat, *per capita* consumption and chicken meat imports are presented in Table 2.2. The *per capita* consumption of chicken meat increased from 0.41 in 1983 to 26 kg per person per annum in 2002. This increase represents an average yearly growth in per capita consumption of 27.4% per person per year.

As illustrated in Figure 2.1, chicken meat production increased rapidly over time. Chicken meat production in 1983 and 2002 was 259 and 38961 tonnes respectively (Table 2.2). Data show that there was an annual average increase in poultry meat production of 43.2 %. There was a decline in meat production of about 25% in 1994, which according to Moreki (2000) was due to shortage of day old chicks, which resulted from an outbreak of Newcastle disease (NCD). Mosinyi (2000) attributed the increase in *per capita* consumption of meat to the change in consumer eating habits and low prices of chicken meat as compared to that of beef, which is significantly higher. The highest increase in *per capita* consumption in chicken meat was between 2000 and 2002 with an average of 20 kg per person per year (Table 2.2 and Figure 2.2). The *per capita* consumption of chicken meat in Botswana is comparable to that of some European countries but lower than the 40 kg per person per year in the United States and Israel

http://scholar.sun.ac.za/

(Mosinyi, 2000). Compared to other countries within the African continent, the *per capita* consumption of chicken meat in South Africa is 27 kg per person per year, which is slightly higher than that of Botswana.

Table 2.2 Chicken meat produced per annum, *per capita* consumption and imports in Botswana from 1983 to 2002

Year	Chicken meat (tonnes)	*Per capita* chicken meat consumption (kg)	Chicken meat imports (tonnes)
1983	259	0.41	169
1984	590	0.55	0.5
1985	922	0.86	33.8
1986	1140	0.99	8.5
1987	1690	1.48	84
1988	1768	1.96	636
1989	2707	2.30	213
1990	2440	2.80	1260
1991	2597	2.95	1382
1992	5244	4.45	873
1993	6155	4.48	739
1994	4605	4.98	2821
1995	7850	6.00	965
1996	7722	5.70	834
1997	11847	7.80	96
1998	15461	10.60	1201
1999	17219	10.90	340
2000	27950	16.10	43
2001	32500	20.00	612
2002	38961	26.00	435

Source: Ministry of Agriculture (2002)

Although the market has experienced an increase in production, chicken meat continued to be imported into the country. However, chicken meat imports although showing some fluctuations, has declined with the increase in local production (Table 2.2 and Figure 2.3). There were increases in imports of chicken meat in 1994 (2821 tonnes), which is ascribable to the outbreak of NCD as previously mentioned. According to Moreki (1997) and Ministry of Agriculture Report (2000), the government encouraged and protected local production from foreign competitors by enacting the Goods and Control Act in 1981, which allows an individual to import only 20 kg of chicken meat at one time. According to this Act, imports of chicken meat by retailers are allowed in the country

http://scholar.sun.ac.za/

when local demand exceeds production. This regulation has partly contributed to the growth of the broiler industry which, according to Poultry Annual Report (2004) has resulted in no imports of chicken meat.

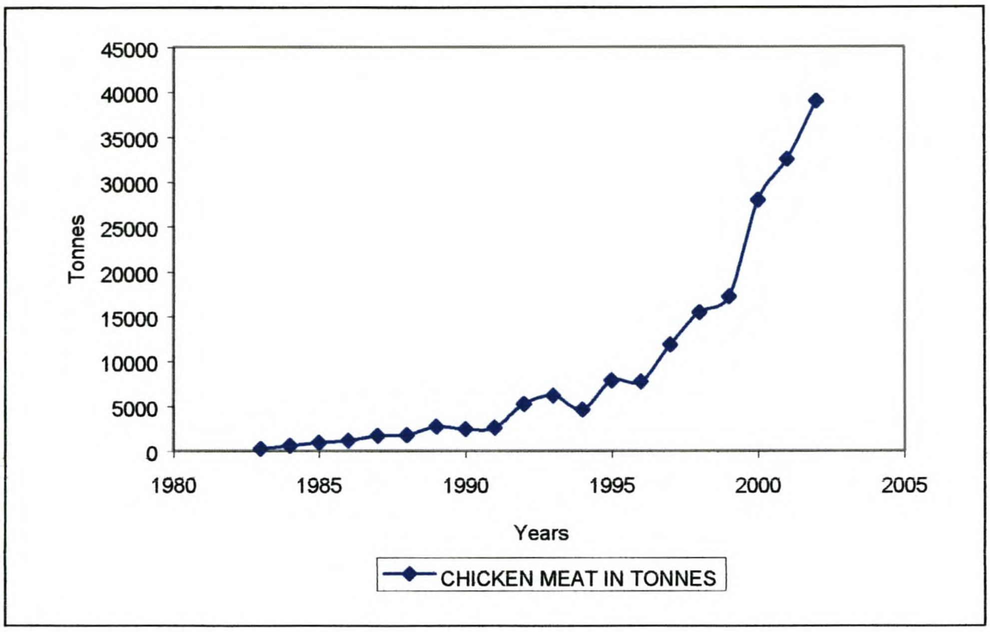

Figure 2.1 Chicken meat production trends from 1983 to 2002

Source: Ministry of Agriculture (2002)

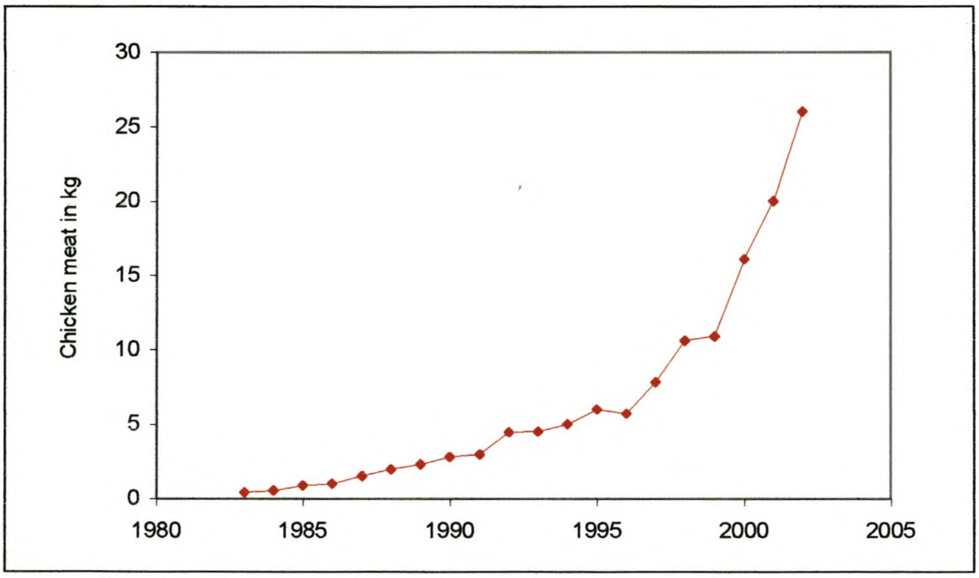

Figure 2.2 *Per capita* consumption of chicken meat from 1983 to 2002

Source: Ministry of Agriculture (2002)

http://scholar.sun.ac.za/

Despite the increase in broiler production that has been achieved from 1983 to date, poultry processed products continue to be imported into Botswana. The importation of poultry processed products, which is currently accounting for 2% of the local meat production is still being allowed into the country.

Table 2.2 and Figure 2.3 show the wide fluctuation observed in chicken meat imports from 1983 to 2002. The unusually high amount of chicken meat imports observed in 1994 may be attributed to the shortage of day-old-chicks as well an outbreak of Newcastle disease as described previously (Moreki, 1997). Looking at the amount of meat imported into the country, a similar pattern is observed in Figure 2.3 below.

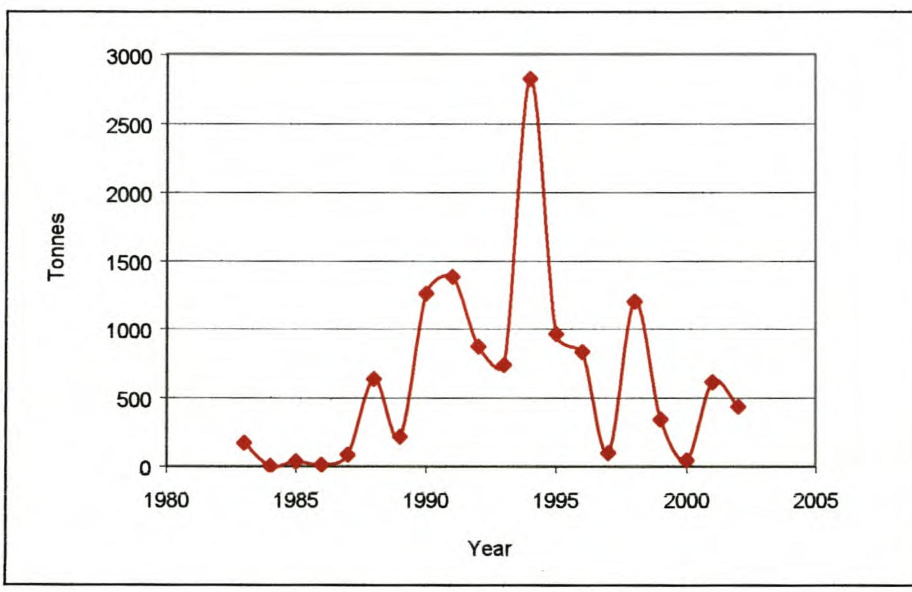

Figure 2.3 Chicken meat imports over a 20-year period from 1983 to 2002
Source: Ministry of Agriculture (2002)

2.6 Conclusion

Although the industry has grown significantly there are still grounds for improvement and this study looked at the two large–scale enterprises in order to evaluate what has been done, where the industry is going and also to identify the potential ways of improving its efficiency.

http://scholar.sun.ac.za/

CHAPTER 3
CASE STUDY

3.1 Introduction

The aim of the case study was to look at the performance of the broiler industry using the two large-scale enterprises as a study model for the study. These two farms were chosen for the following reasons: firstly, the broiler in Botswana industry is small and with few large-scale enterprises; secondly, these two farms maintained good record-keeping practices compared to others and lastly because they provided the production data to be used in this study. The objective of the study was to evaluate the development of the broiler industry in Botswana over a 20 year period to present. The study's focus is on those production parameters such as feed intake (FI), body weight (BW), mortality, feed conversion ratio (FCR) and performance efficiency factor (PEF) that are key to measuring production efficiency in broilers.

The two farms started operations in 1984 as large-scale enterprises producing over 5000 birds per cycle. The farms started operation when the broiler industry was at its infant stage, therefore there were many production problems encountered including inadequate availability of chicks, poor quality of chicks and feeds, inadequate supply of vaccines and drugs. These farms operated with nine houses with an annual five-cycle period. The total annual production was 25000 birds per farm.

3.2 Methodology

As the objectives of the study were to evaluate the development of the broiler industry in Botswana over a 20 year period to present, coverage of the whole country where production takes place would have been desirable. However, due to the fact that small-scale broiler producers do not keep appropriate production records, it was not possible to spread the sample frame that would include them. The country has only five (5) large-scale enterprises. This being the case, only two representative samples of the large-scale broiler producers who provide data of the commercial sector and also keep proper production records have allowed the data to be used in this study.

http://scholar.sun.ac.za/

Data were collected from both primary and secondary sources. Production records over a seven year period were obtained from the enterprises under study as well as different interviews through questionnaires to collect data.

Production records such as mortality rates, feed consumption; live mass (kg) and length of rearing period (days) were obtained from the broiler production records. A short survey was used to collect data on the general performance of the enterprises.

Primary data collected consisted of the farmer's perception on broiler production, farmers' perceptions on support from the extension agents the level of education on broiler management and understanding of the purpose of ventilation and the general broiler management (see Appendix).

Secondary data was obtained from 1996 to 2002 production record sheets and from the Ministry of Agriculture Annual Reports. The type of data collected included FCR, mortality; BW, stocking density, age at slaughter and PEF.

A structured questionnaire was developed to assess employee's perception about the development, performance and profitability of the enterprises. The response for each question asked was looked at, and those of interest to portray information with regards to relationships were established. Tables were produced and percentages determined based on the totals. Survey data were interpreted in both percentages and numerical figures. Production data were analysed using the analysis of variance (ANOVA) and General Linear Model (GLM) procedure of GENTAST Discovery Edition. Differences between means were determined by using a Student's T test.

3.3 Results and Discussion

The study took an overview of the evolution of the two farms over a seven-year period beginning from 1996 to 2002. The farms operations experienced several difficulties that included lack of basic equipment such as feeders, drinkers and brooders. There was also shortage of day old broiler birds and according to respondents; the quality of imported

http://scholar.sun.ac.za/

day old chicks was not good. However, these problems were addressed with the passage of time with the introduction of a local hatchery in the year 1997. The hatchery provides producers with better quality day old chicks and reduced production costs in terms of transportation. It also decreases the stress the day old chicks are subjected to during long journeys. The growth of the industry attracted suppliers of poultry equipment to start business locally where poultry equipment was then supplied locally. As the industry grew, the government initiated a system providing financial support for poultry farmers with imported and subsidized feed, drugs and vaccines and equipment. Feed composition and formulation is critical in the broiler industry, due to the very short productive cycle and the rapid growth rate potentially achieved by these birds. Broiler rations and their names differ slightly from one feed supplier to the other. However, the basic requirement for broiler birds is the metabolisable energy (ME) basically calculated to 12.8 MJ/kg for broiler starter, 13.1 MJ/kg for broiler grower and 13.0 MJ/kg for finisher The protein content of broiler starter is 20-23%, whereas that of grower and finisher diets is 19-20%.

Despite the constraints experienced by the two farms regarding the provision of birds and supply of production inputs, they seemed to operate within acceptable margins. Records indicated that from 1996 to 2002 the two enterprises improved in terms of management, FCR, mortality rates (average 4%) and BW at slaughter (1.8 kg). The same scenario is reflected during the 2001 and 2002 production periods with some changes in the reduction of slaughter age from 43 to 39 days. This could be attributed to improved genetic material of day olds, as well as improved feed quality and the decrease of transport costs.

The data reviews production performance for Farms A and B over a seven-year period (1996 to 2002). The means and LSD's for the production parameters (age at slaughter, BW, cumulative FI, FCR, mortality and PEF) and number of birds reared per farm, are given in Tables 3.1 and 3.2

http://scholar.sun.ac.za/

The average slaughter age for Farm A ranged between 43 days in 1996 to 39 days in 2002. The lowest slaughter age was in year 2001 where birds were slaughtered at 37 days. There has been a gradual change in age to slaughter (43 down to 36) during the period studied. This supports the findings in the trend followed by production parameters and as described previously, can be ascribed to genetic improvements of broiler birds for fast growth, improved nutritional status of the broiler feeds as well as efficiency in management.

Table 3.1 Mean values for age at slaughter (days), body weight (BW) at slaughter (kg/bird), cumulative feed intake (cum FI – kg/bird), feed conversion ratio (FCR), mortality (%), birds produced per year and performance efficiency factor (PEF) for Farm A from 1996 to 2002.

Year	Age at slaughter	BW	Cum FI	FCR	Mortality	Bird No.	PEF
1996	43.44	1.79	4.64	2.59	4.93	25 000	151.13
1997	42.56	1.65	4.50	2.73	4.49	24 989	136.14
1998	37.33	1.44	1.88	1.88	9.50	25 132	198.10
1999	40.89	1.94	3.79	1.96	4.44	24 750	239.81
2000	36.33	1.63	3.05	1.86	3.83	24 864	232.22
2001	37.0	1.85	2.89	1.57	4.62	20 373	305.90
2002	39.33	1.79	3.38	1.87	6.72	26 005	240.83
P values	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
LSD	1.15	0.07	0.16	0.09	2.01	196.2	23.15

Table 3.2 Mean values for age at slaughter (days), body weight (BW) at slaughter (kg/bird), cumulative feed intake (FI) – kg/bird), feed conversion ratio (FCR), mortality (%), birds produced per year and performance efficiency factor (PEF) for Farm B from 19996 to 2002.

Year	Age at slaughter	BW	Cum FI	FCR	Mortality	Bird No.	PEF
1996	41.33	1.79	3.77	2.10	4.65	25 019	196.84
1997	40.89	1.77	3.34	1.88	3.20	25 746	224.42
1998	40.89	1.77	3.34	1.88	3.20	25 746	224.44
1999	40.33	1.94	3.79	1.95	5.51	25 167	230.42
2000	38.56	1.84	3.43	1.86	5.42	24 870	216.8
2001	38.11	1.84	3.12	1.70	5.05	25 032	271.61
2002	36.33	1.69	2.82	1.67	4.42	25 012	266.90
P values	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
LSD	1.19	0.08	0.25	0.11	1.33	402.10	31.06

http://scholar.sun.ac.za/

Data for Farm B, however, showed a similar pattern in that the slaughter age in 1996 was 41 days and it reduced to 36 days in 2002 but BW was substantially lower. This reduction can be ascribed to the improvements in feed efficiency as indicated in Table 3.2 where FCR was 1.67 with BW of 1.69 kg. Reducing the days the birds are housed in the farms has a major impact on the financial status as it reduces some of costs incurred in feed when birds have reached the desired weight. Feed cost constitutes 70% of all production inputs (Hall, 2002).

Both farms started with later slaughter age (43 and 41 days respectively) and reduced the slaughter age to 36 days as the genetic potential of birds improved. According to Dozier *et al.* (2001), the advantage of commercial broilers is that their production cycle is significantly shorter than what used to be; 39 days are needed to for a weight of 1.70 kg. The results of the current study show a similar pattern to the findings of Dozier *et al.* (2001). The reduction could be attributable to development in technology, market requirements and the improved genotype of the broiler birds as fast growing birds were introduced. The improvement in nutritional status could also result in early maturity of the birds.

Not surprisingly, a direct relationship between variables, age at slaughter and BW was found. If the market demands to buy chickens at 1.2-1.3 kg they have to be slaughtered at an early age or when ever they reach that weight. However, BW should not be considered alone when determining age at slaughter. Feed quality and FI are major determinants of the rate at which broilers grow, and have to be brought into consideration when evaluating this parameter.

The delay in age at slaughter and subsequent heavier BW observed in 1999 for both farms (Tables 3.1 and 3.2) could be attributed to many factors such as problem of availability of markets (Havestein *et al.*, 1994).

The average FI per bird per cycle for Farm A for a seven-year period decreased from 4.6 kg to 1.8 kg. It is observed that where FI was highest (4.6 kg) in 1996, BW was not the

http://scholar.sun.ac.za/

highest (1.7 kg) and the age at slaughter was the longest at 43 days. This shows that efficiency was poor as birds ate more feed to compensate for poor environmental conditions and other factors.

The results from Farm B showed that over the same period (1996 to 2002) FI varied from 3.8 kg in 1996 to 2.8 kg in 2002. The scenario in Farm B is somehow different from that of Farm A where one would expect that high FI and age at slaughter would result in high BW gains. However, there is a contrast in that the results showed that when average age at slaughter was 38 days in 2000 and 2001, the average BW was 1.8 kg, and in 1996 FI and age at slaughter were high at 3.7 kg and 41 days, respectively, but the average BW was comparatively lower at 1.7 kg.

The observations recorded here showed that generally FI had a direct influence on BW and perhaps even showed the closest relationships between the two variables. A comparative data on FI and FCR for the two farms was performed. The findings from Farm A showed a decline in FCR from 2.6 in 1996 to 1.6 in 2002. Farm B also recorded a decline in FCR of 2.1 in 1996 to 1.6 in 2002. The average FI for Farm A decreased from 4.6 kg in 1996 to 2.9 kg in 2002.

Farm B has during the same period shown that the FI varied between 3.8 kg with an FCR of 2.1 in 1996 to 2.8 kg with FCR of 1.6 in year 2002. The results indicate that for the seven-year period, FCR showed a declining trend. This can be attributed to improved management.

Data for mortality showed that mortality rates for both farms were in general within the expected range of 5%. However, Farm A experienced an elevated mortality rate of 9.5% in year 1998. This high mortality was attributed to an outbreak of diseases like NCD and Fowl Typhoid (Moreki, 2000). This is comparatively high considering that other averages are between 3% and 6% for both farms. Mortality rates declined with time and were kept within the 5% rate that is accepted as normal (Tables 3.1 and 3.2). This improvement can be ascribed to improvement in husbandry management at the two farms. Changing from

http://scholar.sun.ac.za/

bell drinkers to the more nipple drinkers has also improved the health conditions in the farms. Nipple drinkers have many advantages over bell drinkers, such as a decrease in labour by eliminating the chore of cleaning drinkers. It is claimed that the use of nipple drinkers could improve feed conversion and broiler health since there is a decrease in bacterial contamination of the water. In addition, litter condition is improved since there is very limited wetting as compared to other drinkers (Goan, 2000). These improvements could also be ascribed to the better management systems applied and the improved facilities built on the farms.

These results showed that parameters such as BW and FCR would increase when age at slaughter is highest and would be lower when age at slaughter is reduced, as such the computation of these parameters showed a high significance (P<. 001). The performance of the two farms shows that there has been great improvement on the part of management. The relationship of body weight gain (BWG), FI and FCR for Farm A is illustrated in Figure 3.1.

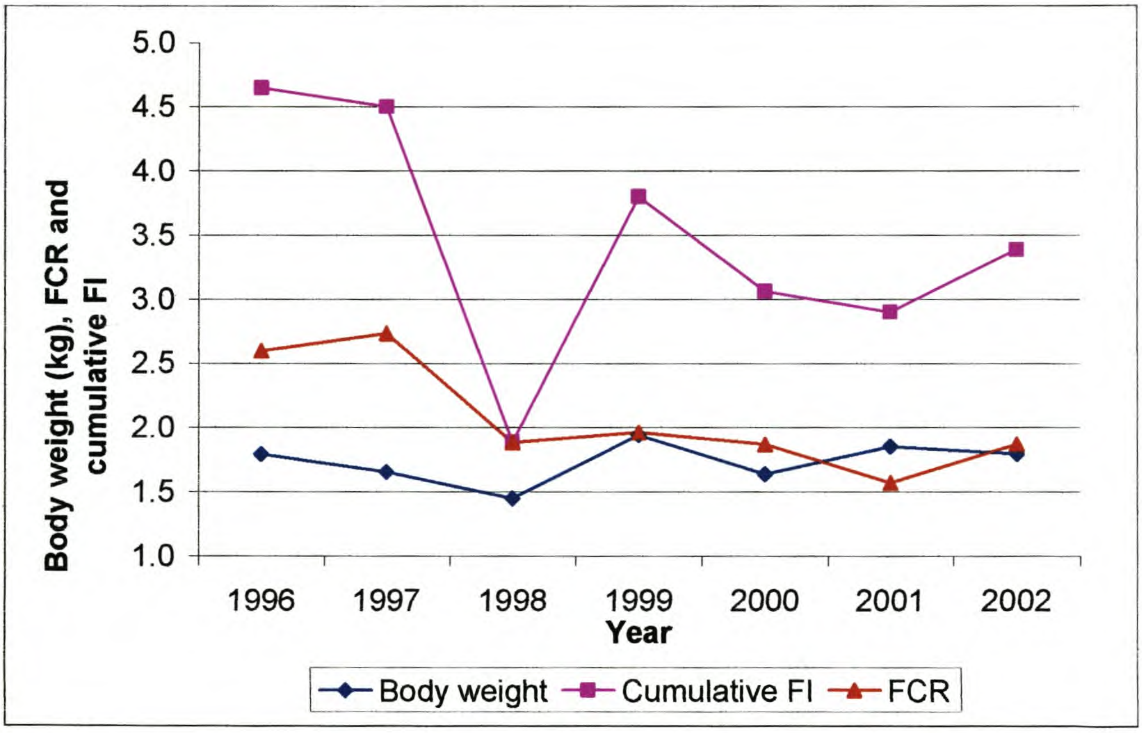

Figure 3.1 Average feed intake, FCR and BW in Farm A from 1996 to 2002

http://scholar.sun.ac.za/

According to Figure 3.1, there is a decline in FI from 1996 to 1998. It is clear from the figure that there was a sharp decline in FI in 1998. The sharp decline in FI is attributed to the high mortality of 9.5% (Table 3.1) recorded during the same year. High mortality is ascribable to poor quality of birds since most of the one-day-olds were still being imported to supplement the hatchery, which was established in 1997. The other reason might be that day old birds were too stressed because of long distances from where they were imported, thus resulting in high mortality. It is clear from Figure 3.1 that the FI increased again from 1988 to 1999 and thereafter declined over time. According to Figure 3.1, there was an increase in FCR from 1996 to 1997 and thereafter a decline in FCR occurred up to 2002. Figure 3.1 indicates that BW did not have a significant pattern in growth, but there was a tendency for BW to increase between 1998 and 1999. The results show that decreased FI resulted in decreased FCR and reduced BW. It could be understood that the first two years of production were compounded with problems associated with birds of low quality, and many management challenges, especially where farmers were to provide a conducive environment for the birds at early stages of growth. At the same time the BW and FCR depicted the same trends until at years 2000, 2001 and 2002, where the BW showed a relative increase when FCR and FI declined. Changes in climate between seasons are known to have a substantial effect on broiler growth and FCR. High temperatures during the summer pose challenges to poultry farmers as they negatively affect FI and hence the decline in feed conversion. The results reported in this study are in agreement with Leeson (2000), who contended that over the years there has been a steady decline in FCR from 2.2 in the early 1960's to 1.75 today under certain situations. This is continuous improvement, which the researcher attributed to improved genetic potential and improved management of the broiler bird.

The high mortality rates on farms observed during 1998 resulted in a significant rise in importation of chicken meat to close the gap of shortfall (Table 2.2). This sharp decline was also observed by Moreki (2000) who attributed the rise in imports to outbreaks of NCD and Fowl Typhoid.

http://scholar.sun.ac.za/

Similar trends were observed in Farm B (Figure 3.2) where FI, FCR and BW declined over time. This decline may be ascribable to the reduction in slaughter age and efficiency in feed utilization due to the genetic potential of the bird, proper housing and other management practices. The finding on BW is in agreement with Groen *et al.* (1998) who contended that BW would improve from 1.5 to 1.8 kg in 35 days of age.

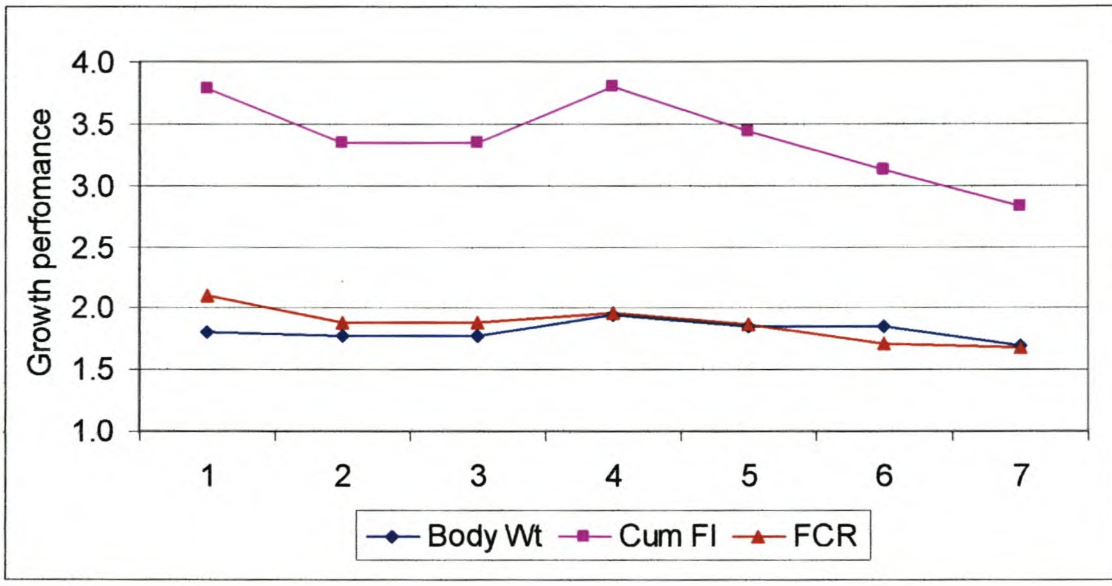

Figure 3.2 Feed intake (FI – kg/bird), Body Weight (Body Wt - kg) and Feed Conversion Ratio (FCR) of Farm B from 1996 to 2002

3.3.1 Gender analysis for Farms A and B

As shown in Table 3.3 the two farms combined employed 77 people (59 females and 18 males). The number and gender of employees is given in Table 3.3.

Table 3.3 Gender of employees at Farms A and B

Name of farm	Male	Female	TOTAL
A	10 (25%)	30 (75%)	**40 (100%)**
B	8 (21.6%)	29 (78.4%)	**37 (100%)**
TOTAL	**18 (23.4%)**	**59 (76.6%)**	**77 (100%)**

http://scholar.sun.ac.za/

Looking at the nature of work, which is very physical (*i.e.* offloading of chicken feed and chicken crates for slaughter), one would expect to see a greater proportion of males employed than females and this is not the case in the current study. The reason for the low number of males employed on the two farms is that female workers are reported to be more committed to work than their male counterparts who either report to work late and/or do not come to work, especially at month ends. A committed workforce is important for broiler production, especially during the first week of the bird's life where brooding is critical. Feed and water should be given at all times to achieve optimum growth of the chickens at a required slaughter age. This indicates the important role women play in the broiler industry and/or poultry industry as a whole.

3.3.2 Employees training

As training in broiler production is crucial for one to attain high performance results from the flock, Farms A and B introduced training of broiler management skills to their employees. Table 3.2 presents data on the skilled and unskilled (knowledge) of workers. The relevance of teaching the farm staff basic management aspects such as brooding, feeding and watering is of outmost importance, as the management applied during this period will impact the remainder of the bird's life. Poor management in the first week is the single major cause of problems later in the growth of the flock. Therefore, the reason for training is to have a good performance of the flock at the end of the rearing period. Generally, good management shown by the two farms can be ascribed to the skills that the workforce acquired.

Table 3.4 Employees training on broiler production

	Status of Training		
Name of Farm	**Trained**	**Untrained**	**TOTAL**
A	28 (70%)	12 (30%)	**40 (100%)**
B	30 (81%)	7 (19%)	**37 (100%)**
TOTAL	**58 (75%)**	**19 (25%)**	**77 (100%)**

http://scholar.sun.ac.za/

As indicated in Table 3.4 the two farms had a total workforce of 77 workers, 58 of whom received training on basic broiler management skills and broiler production, whereas the remainder was not trained. Table 3.4 indicates that in Farm A, 28 workers were trained while 12 were not trained, whereas in Farm B, 30 workers were trained and seven were not.

3.3.3 Managing the environment

Providing a good environment (in terms of temperature and air quality) for the birds during the first three weeks of the birds' life is always a challenging task. In particular, when the farms are not provided with the most modern technology, as it is the case in Botswana where there is no temperature control, especially during hot weather and insulations for adverse weather conditions. Both farms started with gas brooders, but this did not provide enough heat for the birds to be within their comfort temperature. The farms then resorted to the use of coal, which they claimed was cheaper and efficient in providing the entire house with heat. According to May *et al.* (1995), when houses are not maintained at the appropriate temperature, the bird's energy requirements will change. Feed and water intake will be negatively affected resulting in decreasing growth rate and decreasing FCR (Al–Harthi & Macleod, 1996). This in turn, will increase production costs and lead to a decrease in overall profitability of the enterprises.

The relevance of correct temperature control is not limited only to the first weeks of life, but also at the end of the production cycle. At temperatures above 25^0 C heat stress can occur resulting in feed efficiency deteriorating since birds will be reluctant to eat (Al–Harthi & Macleod, 1996). Heat stressed birds can become less active and consume less feed and more water (Daghir, 1995), which can result in decreased live weight gain.

The preparations for broiler houses before arrival of one-day-old chicks is crucial as houses need to be pre-heated 48 hours before the chicks arrive. Chicks need access to temperatures close to 30 °C in their first week of arrival, decreasing to about 27° C to 28° C during the second week. The temperature requirement during the third week is often between 25° ^{0} C and 26° C (Oluyemi & Roberts, 1994). Birds that are not provided with

http://scholar.sun.ac.za/

heat do not grow as fast as those provided with heat, as early growth establishes the maximum weight a bird is likely to be able to gain (Sandercock *et al.*, 1995). The bird's internal heat balance is the most critical factor in maximising growth. When the surrounding air temperature is too cold, the bird has to use feed energy just to keep itself warm. Therefore, the importance of getting birds off to a good start cannot be overemphasised. Environmental factors such as proper brooding, good ventilation and temperature offer the best opportunity to improve flock performance. When birds are unstressed, they are able to maximise weight gain, using more feed nutrients for growth and less for body maintenance. The two farms appeared to have provided sufficient heat for their flocks as indicated by low mortality (Tables 3.4 and 3.5). Farm A used coal as the source of heat for brooding while Farm B used both coal and gas. The respondents said that coal was less expensive compared to gas.

The results of the present study show that significant improvements in the performance of the commercial broilers have been achieved over time. These improvements included increases in live weight, reductions in FCR, mortality and age at which birds were slaughtered (Table 3.3). The results concur with Groen *et al.* (1998) who reported that with good biosecurity programme, optimum management/housing and adequate nutrition, it is quite common to have broilers of more than 1.5 to 1.85 kg at 35 days of age which are comparable to this study with BW of 1.69 to 1.79 kg at 36 and 39 days.

3.3.4 Disease management

Newcastle disease and Infectious bursal disease (IBD) are both of viral origin. These are diseases of economic importance in the broiler sector. NCD causes higher mortality compared to IBD. It is therefore important to vaccinate birds against these diseases. Control of the access of wild birds to the broiler houses is also of paramount importance as birds can be carriers of these highly contagious diseases. IBD affects the immune system of the birds thereby reducing the chicks' immune system. Mortality levels due to IBD can be over 40%. The economic importance of IBD is twofold, as it causes direct mortality and it provides grounds for the development of secondary infections due to sub-optimal immune system.

http://scholar.sun.ac.za/

3.3.5 Vaccinations and biosecurity

The two enterprises carried out stringent disease control measures. The main diseases that were controlled at the two farms were NCD and IBD. NCD vaccines (Strains Hitchner B1 and La Sota) vaccines were used while IBD vaccine (Type 1 and CU 1M for intermediate and mild outbreaks and LC 75 for intermediate plus) was used against IBD. As illustrated in Table 3.5, three vaccinations were conducted during the first 21 days of life and these were administered orally (via drinking water).

Table 3.5 Vaccination programmes for Farms A and B

Age	Route	Vaccine type
10 days	Drinking water	Hitchner B1
12 days	Drinking water	Gumboro
21 days	Drinking water	La Sota

Cleaning in both farms starts as soon as all birds are removed from the houses for slaughter. Normally the shed would be rested for 14 days before restocking, but now changes are developing depending on market demand which forces producers to rest the broiler houses for only 12 days. Equipment such as feeders and drinkers are removed from the houses during the cleaning process. Sweeping and thorough cleaning of all equipment used for rearing the previous flock is done followed by thorough washing and disinfections of the house and curtains. Manure is removed and packaged in bags for disposal 5 km away from the farms. In the past, manure disposal was not a problem as it was spread on agricultural fields. Currently, the issue of litter disposal has become a more sensitive one as more land is taken out of agricultural production. This has resulted in growing concerns emanating from improper disposal of litter, which has resulted in pollution of streams and underground water sources. The current disposal practices involve dumping it 5 km away from the poultry houses, and cover it with plastic sheets. Some composting has also started recently to reduce the volume of litter. The Government is now working on a waste management Act to be enforced in order to reduce pollution and potential dissemination of infectious diseases.

http://scholar.sun.ac.za/

3.3 Conclusions

A comparison of values of efficiency showed that FI is related to BW as it was observed that BW increased with increased FI. Continued improvements in performance as measured by the PEF and time required to produce a bird of a given size, are evident from the results of this study.

Data support the view that there is still ground for improvement of production efficiency. Attainment of maximum genetic potential for growth is dependent upon many factors including the extent to which environmental variables can be controlled (Settar *et al.,* 1999). These results also show average days at slaughter, live weight, FCR, mortality and PEF from the two broiler enterprises that obtained day-old-chicks and feeds from the same hatchery and feed mill, respectively.

The results of the current study showed that age at slaughter, BW, cumulative FI, FCR and mortality at the two farms declined significantly ($P<0.001$) with time (from 1996 to 2002). On the other hand, PEF increased significantly ($P<0.001$) over time. These improvements in performance may be ascribable to the genetic improvements of the broiler bird for fast growth, improved nutritional status as well as efficiency in management on the part of producers.

http://scholar.sun.ac.za/

REFERENCES

Asghar, A., Farooq, M., Mian, M.A., Pervez & Khurhid, A., 2000. Economics of broiler production in Mardan Division. *Journal of Rural Development & Administration.* **Vol. XXXII**: 56-65.

Bains, B.S., 1992. The development of Australian Poultry Industry: Past, present and future. **In**, The Sixth Animal Science Congress of the Asian-Australian Association of the Animal Production Societies (AAAP) Proceedings, **Volume 4,** International Symposium, Sukhothai Thammathrait Open University on 27-28 November, 1992. 57 – 62.

Central Statistics Office, 2004. Ministry of Finance and Development Planning. Gaborone, Botswana.

Daghir, N.J., 1995. Broiler feeding and management in hot climates. **In,** N.J. Daghir (Ed) *Poultry Production in Hot Climates.* Cab International, Wallingford, UK. 185–192.

Dozier, W.A., III, Lacy, M.P. & Vest, L.R., 2001. Broiler Production and Management. Department of Poultry Science, Cooperative Extension Service. The University of Georgia College of Agriculture and Environmental Sciences. Athens, GA 30602.

Emmerson, D., 2000. Efficiency of phase – feeding in broiler. Proceedings, California Animal Nutrition Conference May 10-11, Frenso Calfornia.

Emmerson, D., 2000. Evolving performance in the US broiler and turkey market, WPSA Conference, Montreal.

Emmert, J., 2000. Efficiency of phase feeding in broilers. Proceedings, California Animal Nutrition Conference, May 10-11, Fresno California.

http://scholar.sun.ac.za/

Farooq, M., Mian, M.A. & Asghar, A., 2001. Factors affecting cost of production and net profit per broiler in the Subtropics. *Livestock Research for Rural Development* **13** (1) http://www.cipav.org.co/lrrd/lrrd13/faro131.htm

Groen, A.F., Jiang, X., Emmerson, D.A.C. & Vereijkenl, A., 1998. Education and production: A deterministic model for the economic evaluation of broiler production systems. Animal Breeding Group, Wageningen Institute of Animal Sciences (WIAS), Wageningen Agricultural University, Wageningen. The Netherlands. Hybrid Turkeys Inc.

Hall, M.B., 2002. What you feed *vs*. What you get. Feed efficiency as an evaluation tool. Department of Animal Sciences University of Florida, Gainesville 32611.

Havestein, G.B., Ferket, P.R., Scheideler S.E. & Larson B.T., 1994. Growth, liveability and feed conversion of 1957 *vs.* 1991 broilers when fed "typical" 1957 and 1991 broiler diets. *Poultry Science* **73**:1785-1794.

Kitsopanidis, G. & Manos, H., 1991. Evaluation of the degree of variation in profitability of poultry meat production according to certain factors. *Epitheorese Zootenhnikes Epistemes*. 59-71.

Kleyn, R., 2003. Cost effective broiler nutrition through improved formulation. http://www.spesfeed.co.za/cost_effective_broiler_nutrition.htm

Lacy, M.P. & Vest, 2002. Management of large broiler farms. Cooperative Extension Service, The University of Georgia College of Agriculture and Environmental Sciences and the U.S. Department of Agriculture Cooperation.

Leeson, S., 2000. Poultry Industry – Assessing Efficiency in Broiler Production Department of Animal and Poultry Science University of Guelph, Guelph, Ontario Canada NIG ZW12.

http://scholar.sun.ac.za/

Leesons, S., Caton, L. J. & Summers, J.D., 1996. Broiler response to diet energy. *Poultry Science* **75**: 529-535.

Leeson, S., 2004. Assessing efficiency in Broiler Production. Department of Animal & Poultry Science. University of Guelph, Guelph, Ontario Canada NAG2 W12. 1–4.

Leesons, S., Caston, L.J. & Summers, J.D., 2000. Broiler response to diet energy. *Poultry Science* **77**: 499 – 501.

May, J.D., Lott, B.D. & Simmons, J.D., 1998. The effect of environmental temperature and body weight on growth rate and feed, gain of made broilers. *Poultry Science* **77:** 499-501.

Ministry of Agriculture, 1999. Poultry Farmer meeting held at Denman Rural Training Centre 19 November 1999. Gaborone, Botswana.

Ministry of Agriculture, 2000. Poultry Annual Report, Department of Animal Health and Production. Gaborone, Botswana.

Ministry of Agriculture, 2002. Poultry Annual Report, Department of Animal Health and Production. Gaborone, Botswana.

Moreki, J.C., 1997. Small-scale Poultry Production Systems in Serowe – Palapye Sub-district Botswana. MSc. Thesis. University of Melbourne, Australia.

Moreki, J.C., 2000. Current status of poultry industry, papers presented at the Animal Health and Production Departmental Conference. 8-10 November 2000, National Veterinary Laboratory, Sebele, Gaborone, Botswana. 63 – 68.

http://scholar.sun.ac.za/

Mosinyi, I., 1996. An overview of the poultry industry and quality control in Botswana. Third meeting of the technical committee on meat and poultry held at Lobatse, 23-24 July 1996. Botswana.

Mosinyi, I., 2000. State of the Poultry Industry of Botswana. A paper presented at Botswana Poultry Association Annual Conference held at Oasis Motel, 8 – 10 August 2000, Tlokweng, Botswana.

Naveed R., Durrani, F. R. & Farooq, M., 1999. Broiler production status in district Chakwal. Unpublished report. Poultry Science Department, NWFP. Agricultural University, Peshawar, Pakistan.

Oluyemi, J.A. & Roberts F.A., 1979. *Poultry production in warm wet climates.* MacMillan Press *Ltd.* Hong Kong. 100 – 104.

Poultry & Piggery Annual Report, 1994. Department of Animal Health and Production, Ministry of Agriculture. Gaborone, Botswana. 59-68.

Poultry Annual Report, 2004. Department of Animal Health and Production, Ministry of Agriculture. Gaborone, Botswana. 5-6.

Pule, M.S., 1977. Poultry Annual Conference. Gaborone, Botswana.

Reddy, D.C., 1991. Poultry Production in developing *versus* developed countries. *World Poultry–Misset* 7: 8-10.

Sandercock, D.A., Mitchell, M.A & McLeod, M.G., 1995. Metabolic heat production in fast and slow growing broiler chickens during acute heat stress. *Poultry Science* **36:** 868.

http://scholar.sun.ac.za/

Settar, P., Yalcin, S., Turkmat, L., Ozkan, S. & Cahanar, A., 1999. Season by genotype interaction related to broiler growth rate and heat tolerance. *Poultry Science* **78:** 1353–1358.

Teguia, A., & Beynen, A. C., 2004. Nutritional aspects on broiler production in small-holder farms in Cameroon. *Livestock Research for Rural Development* **16** (1) http://www.cipav.org.co/lrrd/lrrd16/1tegu161.htm

http://scholar.sun.ac.za/

APPENDIX

POULTRY BROILERS STUDY SURVEY

1. Name of Farm……………………………………………………………
2. GenderMale ☐ Female ☐
3. Enterprise Ownership: Sole owner ☐ Company ☐ Group ☐
4. Which area of your farm is used for broiler production? m^2 / ha
5. What is the maximum capacity of your farm…………………………birds.
6. How many broiler birds did you keep in the last three years? 2001………

   2002…………… 2003………………
7. How long have you been keeping broilers?………………months/years.
8. Where do you buy your day old chicks?………………………………………
   ………………………………………………………………………………………
9. How may chicken houses do you have?………………………………………
10. What is the stocking density?………………………birds per m^2
11. How does the stocking density vary according to season?…………………
    ………………………………………………………………………………………
    ………………………………………………………………………………………
12. Where do you buy your feed?…………………………………………………..
13. Is the feed source reliable? Yes ☐ No ☐
14. What comments can you make on the feed e.g. price and quality?………...
    ………………………………………………………………………………………
    ………………………………………………………………………………………
    ………………………………………………………………………………………
15. How often do you visit chicken house per day during the brooding period?

    Once ☐ Twice ☐ Three times ☐ Four times

    Other (specify)………………………………………………………………

http://scholar.sun.ac.za/

16. Do your chickens have resting time at night (no light)?

Yes ☐ No ☐

If yes, how many hours of darkness per night?..............................hrs

17. How many chicks per drinker during brooding period?..........................

18. Do you understand the purpose of ventilation in a broilers unit?

Yes ☐ No ☐

19. Do you recognize when birds are feeling happy or not?

Yes ☐ No ☐

20. What type of brooding system are you using?

....

....

21. What is the rate of mortality at the end of each cycle?

Less than 5% ☐ 10% ☐ 5% ☐ above 15%

22. What feeding programme is practiced in the farm?

Ad-Libitum ☐ Restricted ☐

23. How often do you have visitors in the farm?

Everyday ☐ Weekly ☐ Every two weeks ☐

Monthly ☐ Other (specify)..

24. How much does it cost you to produce 1kg of chicken meat?

....

25. How do you rate financial performance of the farm?

Profit making ☐ operating at break even ☐ at a loss

26. What do you consider to be the main problems in broiler production?

....

....

....

http://scholar.sun.ac.za/

27. What is your level of education?……………………………………………………..

28. Have you ever been trained in broiler production?

Yes ☐ No ☐