SMALL-SCALE POULTRY PRODUCTION SYSTEMS IN BOTSWANA AND EVALUATION OF A NATURAL ZEOLITE IN BROILER DIETS

A Thesis Presented in Partial Fulfilment of the Requirements for the Degree of Master of Science in Nutritional Science at Massey University

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ABSTRACT

Two entirely separate research issues form the two parts of this thesis. A survey of small-scale poultry production systems in Botswana is presented in Part A and an evaluation of a natural zeolite in broiler diets in Part B.

Part A examined the aspects of management, productivity parameters, farm inputs, housing, feeding, diseases and marketing in small-scale poultry farms in Botswana. In both small-scale layer and broiler farms, only a small percentage of producers were below the age of 30 years, probably reflecting the high costs associated with these systems. Clearly young people would not have the necessary capital to start the projects and the finding emphasises lack of credit being a major constraint to the growth of poultry industry in Botswana. In the two production systems, female producers showed a higher percentage of ownership of poultry projects showing that the government policies have achieved the objective of encouraging involvement of women in business.

The average hen day production in small-scale layer farms was 71.7% and the average feed intake was 108.1g per hen per day. Correlation analysis showed that the feed intake was positively related ($P = 0.03$; $R^2 = 0.92$) to egg production. It was observed that hen day egg production was low in farms where feed intake was low, highlighting the importance of providing sufficient amounts of feed. An average of 1 740g of feed was required to produce one dozen of eggs. This feed efficiency level was better than those recorded in some countries, but poorer than the breeder's recommendation (1 580g feed/dozen eggs). Hens were culled after 52 weeks in production (around 78 weeks of age). During this period, a hen produced an average of 245 eggs; this was lower than 300 or more eggs for modern layers under optimum conditions. Factors responsible for the poor layer performance under small farm conditions in Botswana are clearly complex, but poor managerial skills and, poor quality of feed and pullets are major contributing reasons. The lower production levels, however, show that there is room for improvements and also highlight the need for better record keeping. The average mortality from 18 weeks of age to culling was 8.46%. Diseases or conditions reportedly associated with these deaths included Newcastle Disease, prolapse of the uterus and diarrhoea, but none of the producers vaccinated their flocks.

The small-scale broiler farms in Botswana grow an average of 4-5 batches per year. The number of production cycles is determined by the number of sheds in a farm, the interval between broiler batches and the availability of the market in a given location. Most broiler farms adhered to the extension advice of two weeks interval to prevent any disease transmission between batches. The average slaughter age was 48.3 days at an average carcass weight of 1.46 kg. The average amount of feed required to produce a broiler bird was 4.6 kg. The feed conversion ratio for small-scale broiler birds in Botswana was 2.72 kg feed/kg gain, considerably higher when compared to Cobb standards (1.60 kg feed/kg gain). The high feed conversion ratio values in small-scale farms are due probably reflective of, among others, the poor quality feeds, management conditions, length of the production cycle and feed wastage. Correlation analysis showed that when the age at slaughter increases, the average feed conversion ratio is increased ($P = 0.0001$). This finding is of economic relevance in Botswana, because small-scale producers keep the broilers longer to satisfy consumer preferences. But the cost of keeping these birds would be higher than the returns from sales because of decreasing feed efficiency. The average mortality was 9.15%. Diseases or conditions reportedly associated with these deaths included Newcastle disease, infectious bursal disease, diarrhoea, chronic respiratory disease, paralysis of the limbs and coccidiosis. In most cases, productivity parameters recorded in the current study are higher than those used by the Ministry of Agriculture for budgeting purposes.

In the present survey, baseline data have been generated on the performance levels in small poultry farms and the production systems have been characterised. In addition to establishing the production standards, it has raised several issues needing attention. The results showed that the future growth of poultry industry in Botswana is constrained by a number of factors including lack of proper knowledge in poultry husbandry and nutrition, irregular supply and poor quality of feeds and breeding stock, inadequate support services and access to credit, as well as a poor marketing infrastructure. It is also clear that intensive systems of raising poultry may not be financially viable long-term in Botswana, because of the strong dependence on external sources for all major inputs (chicks, pullets, feed etc). The Government, in association with organisations such as Botswana Poultry Association, should formulate policies to address these issues.

The results from a 35-day feeding experiment, conducted to evaluate the influence of a natural zeolite (Mordenite) on the performance of broiler chickens fed maize-soyabean meal diets, are presented in Part B of the thesis. Four levels of Mordenite (0, 2.5, 5.0 and 7.5%) were incorporated in diets formulated to provide similar levels of apparent metabolisable energy, lysine and methionine plus cysteine. Each dietary treatment was fed to ten replicate pens (4 birds/pen). Inclusion of 2.5% Mordenite improved weight gains of broilers by 4.1% over that from control diet with no Mordenite, but the difference were not statistically significant ($P > 0.05$). Weight gains of birds fed diets containing 5.0% Mordenite were similar ($P > 0.05$) to those fed the control diet. There was, however, a significant ($P < 0.05$) depression in weight gain of birds fed the 7.5% Mordenite diet compared to those fed the diet with 2.5% Mordenite. The detrimental effect on weight gain at this level is due largely to the reduction in feed intake. Feed intake of birds fed diets containing 7.5% Mordenite was lower ($P < 0.05$) than those on the 2.5% Mordenite diets. Inclusion of Mordenite at 2.5 and 5.0% had no effect ($P > 0.05$) on feed intake compared to controls. Inclusion of Mordenite to levels up to 5% had no effect ($P > 0.05$) on the feed efficiency of broilers. The inclusion of 2.5% Mordenite, however, caused a numerical improvement in feed utilisation (1.47 versus 1.51g feed/g gain). Feed efficiency was significantly ($P < 0.05$) depressed when 7.5% Mordenite was included in the diets. Excreta nitrogen and phosphorus contents were affected linearly ($P = 0.001$) by increasing levels of Mordenite. Excreta quality scores were not influenced by the inclusion of Mordenite. Overall, the findings are encouraging and showed that the addition of low levels of Mordenite (2.5%) is beneficial in improving broiler production and litter attributes.

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"Sa siiwa tsasting se ikisa meriting: Bojang ja Pitse ke jo bo mo maleng...e bo lebile"

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LIST OF ABBREVIATIONS

ADG	AVERAGE DAILY GAIN
ALDEP	ARABLE LAND DEVELOPMENT PROGRAMME
AME	APPARENT METABOLISABLE ENERGY
BMC	BOTSWANA MEAT COMMISSION
DON	DEOXYNIVALENOL
EDS	EGG DROP SYNDROME
FAO	FOOD AND AGRICULTURAL ORGANISATION
FAP	FINANCIAL ASSISTANCE POLICY
FCR	FEED CONVERSION RATIO
FEPNZ	FEDERATION OF EGG PRODUCERS NEW ZEALAND
GDP	GROSS DOMESTIC PRODUCT
GIT	GASTRO INTESTINAL TRACT
HSCAS	HYDRATED SODIUM CALCIUM ALUMINOSILICATES
IBD	INFECTIOUS BURSAL DISEASE
Kcal	KILO CALORIES
MCI	MINISTRY OF COMMERCE AND INDUSTRY
MFDP	MINISTRY OF FINANCE AND DEVELOPMENT PLANNING
MJ	MEGA JOULE
MMRWA	MINISTRY OF MINERAL RESOURCES AND WATER AFFAIRS
MoA	MINISTRY OF AGRICULTURE
NCD	NEWCASTLE DISEASE
NDP	NATIONAL DEVELOPMENT PLAN
NIV	NIVALENOL
NVL	NATIONAL VETERINARY LABORATORY
SADC	SOUTHERN AFRICAN DEVELOPMENT COMMUNITY
SMME	SMALL, MEDIUM AND MICRO-ENTERPRISES
SZA	SODIUM ZEOLITE A

PART A

SURVEY OF SMALL-SCALE POULTRY PRODUCTION SYSTEMS IN BOTSWANA

CHAPTER 1

GENERAL INTRODUCTION

Botswana's population, estimated to be 1.46 million in 1999, is growing at a rate of 1.1 percent per annum (Anon, 1999). The per capita Gross Domestic Product is estimated at US $3 600 and average life expectancy is 40 years (Anon, 1999). Despite considerable economic progress since independence in 1966, the majority of the population still live in rural areas. It is estimated that about 76% of the population live in rural areas, deriving their livelihood mainly from agriculture (Mazonde, 1993; van Rooyen, 2000).

Despite the rapid economic growth, unemployment remains a major problem in Botswana with the current unemployment rate at 21% (Rebaagetse, 1998). The economic growth has been due largely to the development of the mining sector, which is capital intensive, and hence does not create employment opportunities for most Batswana. The contribution of the agricultural sector to the Gross Domestic Product (GDP) has declined from 40% in 1966 to a low of 4% in 1996 (NDP 8, 1997).

1.1 Background and Problem Statement

Agricultural production in Botswana has plummeted since independence in 1966 to the current low of 4 percent of the GDP (Mazonde, 1993; Anon, 1999). However, it should be noted that agriculture still remains an important source of employment, although the share of the non-agricultural sector in total employment has substantially increased.

In the early 1980s, the Government implemented policies to diversify the economy from one based on diamond mining and beef production to initiating various agricultural projects including pig, small stock (sheep and goats), dairy and poultry production. The primary aim of the diversification was to provide employment to the rural population (Ramosweu, 1999). The Financial Assistance Policy (FAP) was launched during this period to provide assistance to entrepreneurs. The assistance was given in the form of grants where investors were required to make a down payment of a certain percentage towards their grants (MFDP, 1995).

The FAP was reviewed in 1995 and changes were made to the terms of capital investment and qualifications for the grants. Emphasis was placed on assisting rural-based projects and promoting the participation of women in business, and as a result more poultry projects were established (MFDP, 1995). It was envisaged that these projects would increase employment. Financial Assistance Policy funding is classified into three different categories based on the total cost of fixed assets and funding by the Government. The categories include large-scale projects with fixed assets exceeding P1 million[1], medium-scale projects with fixed assets ranging from P75 001 to P1 million and small-scale projects with fixed assets valued up to P75 000 (MFDP, 1995). The poultry industry grew by 11% during 1998/99 reflecting both an increase in the number of new projects and the expansion of existing projects (Rebaagetse, 1998).

Layer and broiler poultry projects are mostly concentrated on the eastern part of the country. This is due mainly to the proximity to markets and easy availability of inputs. Currently, the annual local production is estimated at 17 219 tons of broiler meat and 4.7 million dozen eggs (MoA, 1999). During 1999, broiler meat imports were only 2% of the total production indicating that Botswana is 98% self-sufficient in broiler meat production. Similarly, 99% of eggs were produced locally with only 1% imported (MoA, 1999).

Although increased growth was recorded in broiler projects, growth in egg production during 1999 was negative. The industry is constrained by supply problems as well as increasing price of inputs. It is therefore not surprising to see layer projects being abandoned or operating below capacity.

1.1.1 Botswana poultry industry

Until the early 1970s, the poultry industry in Botswana was based on indigenous birds kept by almost every household in rural areas, supplemented by imports of eggs and poultry meat from neighbouring countries (Mosinyi, 1986). The village poultry still plays an important role in rural areas supplying the rural population with an additional source of income and animal protein intake. The commercial poultry industry in

[1] \$0.1788 US = P1.00 (October 04, 2001). The local currency (P) is called Pula.

Botswana started during the 1970s. With support from the Government, the industry has experienced significant growth during the past three decades. Both the broiler and layer industries are currently self-sufficient, although the layer industry is undergoing negative growth. The Government, under the three categories discussed in Section 1.1, provides funding for commercial poultry projects in Botswana. All small-scale poultry projects are Government funded, while most medium and all large-scale projects are self-funded. On average small-scale layer projects have flock sizes ranging from 500 to 1000 hens per production cycle while the range for broiler operations is 500-1500 birds per batch. Large-scale producers of broilers in Botswana are Tswana Pride, Dikoko Tsa Botswana, Richmark Poultry, Shashe Farms and Goodwill Chickens, while the major large-scale egg producers are Ace Poultry Farm, Notwane East Poultry Farm, Greenway Farm, Makome Hill Farm and Ladybird Farm (MoA, 1999). "National Chicks Botswana" plays a major role in the supply of day-old broiler chicks, while some private agents also import and supply chicks. The import and supply of replacement pullets are totally in the hands of private agents.

1.2 Objectives of the Study

Very little literature is available on small-scale poultry enterprises in Botswana. The objective of the present study was to obtain baseline information on specific aspects of production systems and productivity in small-scale poultry farms. For the purpose of the study, the size of the operation is classified based on the total cost of fixed assets. Small-scale poultry operations are defined as those valued up to P75 000 in terms of fixed assets. Small-scale projects were selected in the present study because they comprise about 80% of the total poultry projects and have important socio-economic implications for the rural-based majority of the Botswana population.

The single-visit, questionnaire survey covered 14 layer farms and 59 broiler farms in two areas of the Central District in Eastern Botswana. It was envisaged that the final outcome would be the identification of constraints faced by the industry and areas to improve productivity.

1.3 Relevance of the Research

The findings from this study are expected to provide valuable information for the Government of Botswana (Ministry of Agriculture) and those ministries working on development issues such as the Ministry of Finance and Development Planning. The Ministry of Agriculture (FAP Section) will benefit from factual data on the productivity and economics of small-scale poultry projects. Such information will assist the FAP section in its decision-making on the future of grants for poultry production in Botswana.

Most importantly, this study will establish a benchmark for follow-up surveys and research in Botswana. It will also provide a better understanding of the problems faced by the industry.

1.4 Limitations of the Study

The study was a single-visit questionnaire survey, which may not have provided enough time to obtain accurate information from the respondents. Importantly, there was no opportunity to cross-check the productivity data provided by the respondents. Throughout the entire research process, poor record keeping at farm level acted as a constraint. In some instances, there are indications that the poultry producers, who attended the Department Poultry Production Courses, used the standard values given during the courses to complete the questionnaires, rather than providing their farm values.

1.5 Outline of Part A of the Thesis

This introductory Chapter provided a brief background on the economy of Botswana and the status of the poultry industry. The study problem was then identified and the objectives defined. A review of literature is presented in Chapter 2, followed by the results from the field surveys. The results from small-scale layer and broiler farms are discussed in Chapters 3 and 4, respectively. A general discussion of the overall results, along with future recommendations, is presented in Chapter 5.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Poultry production is growing rapidly worldwide and the growth of the industry has been impressive in some parts of the world. World poultry meat production exceeded 62 million tonnes in 1999, which has shown an increase of 4% above the 1998 production figures (Anon, 2000). During the period 1995-1998, chicken meat production grew fastest in South America (24%), increasing this region's share of the world total to 14.5%. In North and Central America, the industry expanded by 19%. In African countries, only a small increase was reported and their world share declined to 4.5% (Anon, 2000). In the layer sector, 56% of world egg production occurs in Asia followed by Europe. However, the South American industry has shown steady increases (up to 5%).

In southern Africa, South Africa was the largest poultry producer, producing 10.5 million broilers per week in 1996. In comparison, the neighbouring states (i.e., Botswana, Swaziland, Mozambique, Lesotho, Zimbabwe, Malawi, Zambia and Namibia) produced only 1.24 million birds per week during the same year (Coetzee, 1996).

In this chapter, literature on trends in animal production, poultry production, government programmes and the structure of the poultry industry in Botswana are reviewed with special emphasis on the importance of small-scale projects. Since published data in these aspects is limited, an overview of all areas relevant to the study objectives is also provided.

2.2 Trends in Animal Production

The agricultural sector's contribution to the gross domestic product of Botswana decreased from 40% at independence in 1966 to 4% in 1996 (NDP 8, 1997). This represents a 90% decline over a thirty-year period. The agricultural sector includes livestock, fisheries, crop and forestry production systems. Nevertheless, the sector remains an important source of food, income, job creation and capital formation for a significant number of Batswana living in rural areas.

2.2.1 Cattle production

Beef production is the dominant agricultural activity in Botswana, contributing about 80% of the livestock sector's Gross Domestic Product (GDP). The current estimates indicate that the national herd is about 2.5 million cattle (Ramsden, 1999). These are kept under two production systems, namely ranching and communal grazing systems. The Botswana Meat Commission (BMC) is the major buyer of livestock and has the monopoly to export all livestock and livestock products. There are three export abattoirs with a total capacity of 300 000 cattle and 120 000 small stock (sheep and goats) per annum (Ramsden, 1999).

The BMC exports over 90% of its beef products with the majority going to the European Union, the Republic of South Africa and Norway. The rest is sold locally. During 1996/97, the production of chilled and frozen boneless beef totalled 16 282 tons, of which 13 507 tons were exported to the European Union and Norway (Ramsden, 1999). This amount represented 70% of BMC's turnover for the year. Due to these market opportunities, Botswana has significant investments in the cattle industry and promotes the interests of large cattle-owners in many ways, including veterinary support, development of water supplies and maintenance of a low taxation regime. The industry has become a "net recipient of public funds, whereas in the colonial period it had been a contributor" (Mayende, 1994, p. 498).

2.2.2 Sheep and goat production

Apart from local butcheries around the country, BMC has been the main marketing agency for small stock. Small stock meat is sold both locally and in the Republic of South Africa. During the period 1989-1992, the supply of sheep and goats to BMC fell by 52% from 24 093 to 12 528. This decline was even more dramatic by 1995 when only 5 206 small stock were slaughtered by BMC. It is possible that lack of marketing facilities and lower producer prices have constrained the growth. These figures, however, may not be representative of all small stock slaughtered in the country.

Since 1995, the availability and increased utilisation of the Financial Assistance Policy (FAP) funds has resulted in a 50% increase in small stock projects. Despite this increase, growth in production is constrained by high mortality rates of sheep and goats as a result of poor management, weak extension and inadequate technical support. The national flock is currently estimated at 2.5 million sheep and goats (Ramsden, 1999).

2.2.3 Pig production

An interest is steadily developing in pig production due to an increasing demand for pork and bacon. This is probably because of an increasing foreign influence on society and also Government policies. Chabo *et al.* (2000) suggested that the demand for pig meat and products was related to an increasing household income and nutritional awareness. Few piggery projects were available prior to the early 1990s because of a lack of a market for pig products in Botswana. The expansion of the industry is limited by shortages of weaner pigs and breeding stock. To address this, the government started a pig-breeding farm in 1975 at Sebele (Nkane, 1986). However, failed to meet the demand due to management problems. In 1995, this pig multiplier unit supplied only 234 of the 903 weaner pigs requested by farmers (Chabo *et al.*, 2000).

A total of 5 000 pigs with a mean carcass weight of 53kg were slaughtered in Botswana abattoirs in 1995 giving 265 tonnes of pig meat. However, during the same period the estimated demand for pig meat was 720 tonnes per annum (MoA, 1995). The local pig production supplied about 37% of the demand while the other 63% was imported from neighbouring countries such as the Republic of South Africa.

2.2.4 Poultry production

Local poultry production increased by 150% between 1991 and 1995 leading to a 40% reduction in poultry imports. However, the country still depends on imports for day-old chicks and point-of-lay pullets to supply poultry projects. The increase in poultry projects is attributed to Government policies especially the FAP where grants for small-scale projects were increased to P75 000 in 1995. The country is currently self-sufficient in chicken meat and eggs.

Per capita consumption of eggs in 1986 was estimated at 12 eggs per year and that of chicken meat was 0.99 kg per year (Mosinyi, 1986). Consumption has steadily increased since then due to growth in the poultry industry and was estimated to be 31 eggs and 7.8 kg chicken meat per capita in 1997 (Mosinyi, 1999). Despite this impressive increase, these values are still considerably lower than developed countries. For example, per capita consumption in New Zealand was estimated at 280 eggs and 25 kg chicken meat in 1997 (Anon, 2000).

The development of the poultry industry has been a priority in a number of Government's programmes of food production, import substitution to save foreign exchange and job creation to reduce unemployment (MFDP, 1995). The country produced 17 219 tons of chicken meat and 4.7 million dozen eggs in 1999, resulting in a P98 million saving (Mosinyi, 1999).

2.3 Government Policies

At independence in 1966, the rural population was involved mainly in agricultural activities that contributed 40% to the GDP of Botswana. The economy of Botswana has since undergone marked changes and the GDP is now dominated by the mining industry. The agricultural sector currently contributes only 4% to the GDP (NDP 8, 1997). The agricultural sector is of a subsistence nature and is influenced by climatic conditions. Recurrent droughts have had serious impact on agricultural output in recent decades.

The Agricultural Policy of 1991 was put in place by the Government to review the performance of the agricultural sector, and to play a meaningful role in agriculture promoting sustainable development. One aim of the policy was to determine the impact of agriculture on the economy and the rural population. The major policy objectives were:

- To improve food security at both household and national levels;
- To increase agricultural output and productivity;
- To diversify the agricultural sector in commodity production and production systems to ensure efficient use of resources to improve investment opportunities and income generation;
- To provide a secure and productive environment for those engaged in agriculture; and
- To conserve scarce agricultural and land resources for future generations.

Several programmes were proposed within the Agricultural Policy to address the problem of food insecurity in Botswana and to ensure sustainable development of the agricultural sector. These policies included the Food Security Policy, the Policy on Diversification (Financial Assistance Policy) and the Policy on Technology Development (Ramosweu, 1999).

2.3.1 Financial assistance policy (FAP)

The FAP was launched in 1982 to diversify the Botswana economy from a beef and diamond base to include such sectors as poultry, dairy, pigs and small stock. This policy led to an incentive scheme aimed at providing financial assistance to the establishment of new and expanding business ventures in manufacturing, agriculture and other productive sectors of the economy (Rebaagetse, 1998). The review of this policy in 1995 recommended that service sectors such as tourism, also be included (MFDP, 1995). The main objectives of the policy are employment creation, economic diversification, import substitution and encouragement of Batswana participation in economic growth. The FAP is coordinated by the Ministry of Finance and Development Planning (MFDP) (MFDP, 1995), but sectoral ministries like the Ministry of Commerce and Industry (MCI), the Ministry of Agriculture (MoA) and the Ministry of Mineral Resources and Water Affairs (MMRWA) also play major roles in the policy implementation (MFDP, 1995). The FAP unit at the National Development Bank is responsible for the disbursement of funds to approved projects and for auditing adherence to the agreement between the Government and the beneficiary on behalf of MFDP (MFDP, 1995).

A review of the performance of the FAP-funded projects indicated that FAP grants were approved for 3 533 small-scale (up to P75 000) projects during the period 1982-1998 (Rebaagetse, 1998). Small stock projects received the highest share of funding (47%), followed by poultry (26%), horticulture and fishing (10% each), while other sectors such as dairy, pigs, beekeeping made up for the remaining 7%.

A total of 212 medium-scale (P75 001 – P1 million) projects were approved for FAP support during the period reviewed (1982-1998). In this category, the majority of the projects were horticulture (29%), with dairy and poultry being 26%, each. Other agricultural enterprises including lumber, small stock, banana plantations, rabbits, fodder and pigs accounted for the remaining 19%. The total approved grants for the agricultural enterprises amounted to P114 million. The government had anticipated that these projects would create over 10 000 jobs for Batswana, but the actual employment generated was only around 3 000 persons (Rebaagetse, 1998).

A proportion of the projects approved failed to start operating. This was due to the failure of applicants to furnish the down payment required; particularly in the case of small-scale projects. Lack of capital and access to credit facilities seemed to affect a large number of small and medium entrepreneurs (Mosinyi, 1999). It is reported that the failure of small-scale projects is due mainly to lack of business management and entrepreneurship among the promoters, lack of commitment, poor project appraisal and monitoring and political interference resulting in non-viable projects being approved (Rebaagetse, 1998).

Of the total approved projects during the 1982-1998, only 2 099 (59%) are operational at small-scale, while 949 (27%) have collapsed. A total of 280 (8%) applicants failed to pay their contribution, while 205 (6%) projects never started production (Rebaagetse, 1998). It is estimated that failed projects resulted in a loss of 2 472 jobs, showing that FAP did not achieve its target in terms of creation of employment opportunities for Batswana (Rebaagetse, 1998).

2.3.1.1 Objectives of the Financial Assistance Policy

The main objectives of the FAP are (MFDP, 1995):

1. Employment creation

Despite a rapid economic growth over the last 30 years in Botswana, unemployment has remained a major problem with the current unemployment rate at 21%. This rapid economic growth has been due to the mining sector, which does not create many employment opportunities. In this regard, the aim of FAP is to assist in the creation of sustained employment opportunities in other sectors.

2. Diversification of the economic base of the country

Before the inception of the FAP, the economy of Botswana depended on two sectors, namely diamond and beef; both are vulnerable to price fluctuations in the world market.

3. Rural development

A high percentage of the population still resides in the rural areas and rural development has been regarded as a priority since independence. It is with this approach in mind that the National Development Plan 8 (1997) addressed the reduction of both relative and absolute poverty through increased income and employment creation. Consistent with this objective, FAP favours projects located in rural areas.

4. Encouragement of active citizen and women participation and ownership of economic ventures

In comparison to foreign-owned businesses, Batswana and women are encouraged to participate in business by the provision of higher grants. Under the small-scale category, women-owned projects are given 15% weightage over their male counterparts. This small-scale category was made available only to citizens of Botswana.

2.3.1.2 Review of FAP

The FAP was reviewed three times, in 1984, 1988 and 1995, to evaluate its effectiveness. A fourth review is currently underway. Each review has recommended the continuation of the programme, with the conclusion that it is has contributed to the economic diversification and created employment (MFDP, 1995).

2.3.1.3 Constraints of FAP projects

Various factors have affected the performance of individual FAP projects. Some are general and affect almost all projects (Rebaagetse, 1998).

♦ Lack of commitment by producers

Some producers are not committed to their projects. Some investors leave management responsibilities to unqualified workers. In other situations, there is great concern at the level of fraud, abuse of FAP funds and cases of collusion between applicants and suppliers of equipment and materials.

♦ Lack of technical expertise in terms of crop and animal health management.

♦ Poor farm and business management as well as marketing skills among entrepreneurs. Poor record keeping among farmers also hampers the success of projects as this affects control and monitoring of the projects.

♦ Poor project selection and screening: it is often the case that during appraisal, projects are not thoroughly screened to establish their economic viability.

♦ High mortality in small stock projects, usually resulting from poor animal husbandry management.

♦ Shortage of water.

♦ High costs of feeds and poor supplies.

♦ Shortage of land for agricultural enterprises, as fertile land suitable for agricultural production is sometimes allocated to other industries.

♦ High water and electricity tariff charges.

♦ Lack of access to credit.

♦ Difficulty in accessing inputs.

♦ Poor project monitoring.

♦ Poor technical support by Government imparting managerial skills to investors, particularly at the small-scale level.

2.3.2 Small, Medium and Micro-Enterprises (SMME) Policy

Though the Government has put in place FAP to assist new ventures and expand existing projects, approved projects are often delayed. This is due mainly to the inability of applicants to furnish the down payment because of lack of access to credit facilities from the financial institutions (Mosinyi, 1999). Introduction of the SMME policy in 1998 was aimed at overcoming this problem. Under this policy, the establishment of a Micro Credit Scheme was proposed. Features of the proposals are outlined below:

· Loans should be made available in the range P500 – P20 000.
· Loans should be short-term (repayable within 6 – 18 months).
· Loans should be available only to citizens of Botswana.
· Loans should be available for any type of business.
· Loans should be available without collateral but would require personal guarantees from the borrower and perhaps also from other guarantors.
· All borrowers should start with smaller loans before being given larger loans.
· The interest and administration fees charged on loans to borrowers should be sufficiently high to ensure that the scheme is sustainable.
· All borrowers should participate in a one-day training course (paid for by the Government) before accessing the first loan. This course should focus upon cash management. Thereafter, attendance at further courses may be made compulsory before graduation to large loans.
· In view of the problems associated with the administration of small scale FAP, it was recommended that the micro-lending scheme should be run by an institution(s), independent of Government.

It should be highlighted that the recommendations of the SMME Task Force were not implemented in their entirety, especially the recommendation on interest rates. The Government took a firm position on the issue relating to the interest rate to be charged in loan advances, which was set at 18% per annum. However, the interest rate was too high for many farmers.

2.3.3 The Food Security Policy

Under this policy, priority is given to production systems and programmes that are sustainable, resource efficient and environmentally friendly. The policy promotes diversification of agricultural resources, their efficient use for increased domestic production and trade to meet local demand (Ramosweu, 1999). Importation of food from other countries is allowed only when there is a shortfall. The Food Security Policy has enabled free importation of food grains by private traders.

2.3.4 Arable Land Development Programme (ALDEP)

The ALDEP was designed to help the development of the rural population, which is the most needy and biggest proportion of the population. In addition, small-scale agriculture forms the basis of the livelihood of this group. The Botswana Government introduced the ALDEP in an attempt to provide small farmers, who do not qualify for credit assistance at subsidised prices, with access to basic farm requisites. The current phase focuses on the most needy section of the community such as women farmers and the old. The packages offered includes animal drawn implements, threshing machines, chaff cutters, fencing materials, mini silos, animal draft power, canoes and scotch carts. Mayende (1992) argues that ALDEP has never benefited the small-scale peasant sector. Rather, it has become clear that the main purpose of the policy was to expedite commercialisation of the cattle industry, from which mainly cattle barons have benefited.

2.4 Poultry Production

There are two poultry production systems in Botswana namely, the traditional village chicken system and the commercial system. The village (Tswana) chicken system is operational only at rural level with a minor impact on national egg and meat production. The rural population use the products from this system for home consumption and any surplus is sold to neighbours. Commercial poultry production in Botswana is characterised by production of eggs and broiler meat in small, medium and large-scale operations. According to the Government FAP, these three categories are classified according to the total cost of fixed assets. The total cost of fixed assets for small-scale operations are up to P75 000, while the total costs for the fixed assets in the medium-scale range from P75 001 to P1 million and for the large-scale operations is from P1.1 million upwards.

Poultry farming in Botswana is important for various reasons, including:

· Meat and eggs - Chicken meat is becoming more and more popular with consumers; white meat is considered healthier than red meat such as beef.
· Income generation - A source of income from the sale of eggs and meat.
· Fertiliser value - Chicken droppings are valuable as manure in crop fields and vegetable gardens.
· Feed value - Droppings have high nitrogen content and have a potential for use in ruminant feeds as a source of non-protein nitrogen.
· Employment - Poultry production, irrespective of the scale of operation, helps in creating jobs for the local community.

2.4.1 Village chicken

Scavenging village chickens play a significant role in poverty alleviation and gender equity enhancement among the disadvantaged communities in developing countries (Saleque, 1996; Tisdell *et al.*, 1997). Chickens form a common resource for different gender groups in the rural population to which the landless and those who do not possess cattle, sheep or goats attach high socio-economic value (Kitalyi, 1997). It is generally considered that the absence of village chickens in any family is a sign of poverty.

Traditional chickens have existed in villages from time immemorial and they form part of the whole farming system. The type and management of chickens kept are influenced by various biological, cultural, social and economic factors prevailing in the villages. This explains the reason why village chicken may comprise a mixture of indigenous birds and some improved breed crosses (Mushi *et al.*, 1999). The nourishment of these birds depends on the feed available in the village, the bird's health and the local disease situation (Kitalyi, 1997).

There are about 3 billion scavenging chickens in the villages of the developing world. These provide nutrition for families, a small cash flow, a reserve for times of celebration or need, a sanitation service and, in some areas, contribute to healing ceremonies, religion and recreation (Roberts, 1992). Sonaiya (1990) estimated that village chicken constitute over 50% of the total poultry population in Africa and contribute 30-80% of total national poultry products.

2.4.1.1 Characteristics of the village chicken production systems in Africa

Village chicken production systems in Africa are based on indigenous breeds and are characterised by low levels of input and output. The main input is feed from household refuse as well as that scavenged around the village (Gueye, 1998). Housing, additional feed and health-care vary greatly within and between countries, and depends on the farmer's socio-economic circumstances. Kitalyi (1997) and Van Marle-Koster and Webb (2000) stated that with this low input, the village chicken is capable of generating cheap and readily harvestable meat and eggs for immediate home consumption and sale for income generation, while at the same time performing a useful social hygiene function. Generally, village chicken producers keep small flocks of between 5 and 20 birds per household (Gueye, 1998).

In most African countries, policy-makers have marginalised the village chicken because of its low productivity compared with commercial poultry production systems. This has led to poultry improvement programmes focusing on the introduction of specialised or exotic breeds, crossbreeding and management intensification. The low feed resource base at the village level and a lack of understanding by the villagers of the complex biological, cultural and socio-economic relationships, however, have limited the progress of these programmes (Kitalyi, 1997). The Government of Botswana, in its National Development Plan (NDP8, 1997), set aside funds for research on the local (Tswana) chicken. This breed is prevalent in rural areas, where they scavenge for feed and roost in the backyards (Ames & Ngemba, 1986). Under these conditions, egg production and growth rates are low, and mortality is high.

2.4.1.2 Rural poultry improvement programmes

In most African countries, the biggest portion of the funding allocated to poultry improvement programmes is for the establishment of centralised farms for the production of fertilised eggs, pullets or cockerels. In some countries, this approach has failed due to poor performance levels and lack of good management by Government employees who head the programmes (Creevey, 1991). The Food and Agriculture Organization (FAO) of the United Nations approved programmes in Ethiopia and Gambia to assist rural women in protecting their village chickens from Newcastle Disease (NCD) and a rural poultry improvement programme in Kenya that included a cockerel exchange scheme (Kitalyi, 1997). Evaluation reports showed that the former projects did not succeed due to poor community participation and weak research-extension linkages, while the latter was a success due to the flexibility of the project and its incorporation of participatory approach techniques and an intensive training component (Ngunjiri, 1995). Overall, the areas which require special attention in rural poultry improvement are the development of a sustainable NCD disease programme, strategic feeding supplementation using locally available feed resources, development of farm-level skills and entrepreneurship, and a consideration of the biological, cultural, social and economic dimensions of the production system.

2.4.1.3 Diseases and parasites

Birds kept under low input systems in rural areas experience high mortality as a result of disease, accidents and predation. The incidence of diseases is one of the principal constraints to these production systems. The resource-poor village poultry farmers in Africa do not have the money for, or access to, medication for disease treatment or to other cost effective disease control measures. There is a general reliance on ancestral indigenous knowledge to control various poultry diseases (Gueye, 1999).

Newcastle Disease is the most widespread infectious disease in Africa and its symptoms are clearly described by village poultry keepers (Bell & Mouloudi, 1988; Cumming, 1994; Gueye, 1999). Cumming (1994) reported that NCD appears in a very severe form, which often kills 100% of the birds. Gueye (1999) reported that disease accounts for 56% of annual losses suffered in Nigeria and The Gambia. Other causes of mortality reported were parasites (17%), cats (15%), snakes (4%), accidents (4%) and bees (4%). In sub-Saharan Africa, it has been estimated that mortality of indigenous chickens can be as high as 53% (Gueye, 1999).

Different vaccines, including conventional ones have been used in several developing countries with high success in the prevention of NCD in village chickens. However, the problems of sustaining the cold chain (to maintain the viability of the vaccine virus during distribution) and the cost involved in catching and vaccinating widely spaced small flocks have proved to be major obstacles and many vaccination schemes have been unsuccessful (Cumming, 1994). The Australian V4-feed supplied vaccine was developed to overcome these limitations. The strain of virus contained in this vaccine is more tolerant to poor storage conditions and may prove a useful tool when used as a conventional vaccine (Cumming, 1994; Spradbrow, 1994).

Other diseases that cause losses in village chicken include fowl pox, fowl typhoid and fowl cholera. Serological evidence has also shown the presence of infectious bronchitis, Marek's disease, *Salmonella pullorum*, *Mycoplasma gallisepticum* and *synoviae*, including avian encephalomyelitis in indigenous chickens (Bouzoubaa *et al.*, 1992; Cumming, 1994). Clearly a whole range of known poultry disease organisms affect village chickens. However, treatment and preventive measures are available for these diseases, these are seldom used in low-input village chicken production.

2.4.1.4 Productivity of indigenous chicken

There is little published data on the productivity of village chickens. A study conducted in Sri Lanka showed that the average flock size of village chickens is about 10 birds. The hen day production was 30%, while the hatching rate was 67% (Gunaratne *et al.*, 1992). The mortality rate in chickens was 65% at 70 days of age. The growth rate of birds was variable, with body weights ranging from 41 to 100g at 20 days, and 142 to 492g at 70 days. The mean age at first lay was 211 ± 36 days, when the pullets weighed 1160 ± 227g. The laying pattern of village chickens was variable, with some birds laying every other day and others laying for two or three days then resting for one or two days. The average clutch size was 20 with an average egg weight of 48 ± 3g (Gunaratne *et al.*, 1992).

In comparison, African data shows that the average flock size ranges from 5 to 20 birds. Gueye (1998) reported that the adult females weigh approximately 1 kg and adult males seldom weigh more than 2 kg. However, there is variation in body weights with the Baladi breed in Sudan and Tsabatha in Cameroon characterised by heavier body weights. The eviscerated carcass yield of indigenous chickens has been estimated to be 64% in mature males and 54% in mature females in Nigeria, and 79% in males and 67% in females at 25 weeks of age in Senegal (Gueye, 1998). Compared to commercial flocks, indigenous chickens are late maturing. Gueye (1998) estimated that sexual maturity of female birds in Sudan occurs at 32 weeks, 24 weeks in Mali and Nigeria, 28-36 weeks in Benin, 25 weeks in Senegal and 28 weeks in Tanzania. However, this author states that with improved feeding and husbandry systems, sexual maturity may be achieved earlier. The annual egg production for indigenous birds in Africa ranges from 20 to 100 eggs with the average egg weight ranging from 30 to 50g (Gueye, 1998).

2.4.1.5 Marketing of indigenous chicken

Live birds are sold in open markets in either villages or towns when cash is needed. Indigenous chickens generally fetch a higher price compared to commercial chickens because the consumers prefer their meat and eggs.

2.4.2 Commercial poultry production in Botswana

Currently, there are a total of 97 layer and 350 broiler commercial small-scale projects in Botswana (MoA, 1999). Chicken meat production increased by 30.5% from 1997 to 1998 and by 11.4% from 1998 to 1999 (Table 2.1). As a result, a total of 2 516 jobs were created in 1999. During 1999 a total of 17 219 tons of broiler meat and 4.7 million dozen eggs were produced locally (MoA, 1999). On average over 100 000 broiler birds are slaughtered weekly in Botswana which translates into about six million broiler birds per year.

The 27.7% increase in egg production was recorded from 1997 to 1998, but a 5.2% decrease in production was recorded from 1998 to 1999 (Table 2.1). This decrease in production resulted in imports of 567 000 eggs during the year 1999 up from 132 300 eggs imported in 1998 (MoA, 1999). However, the general trend is an increase in local production of chicken meat and eggs throughout the period (1982-1999) with concomitant decrease in imports.

Table 2.1. Production of chicken meat and eggs in Botswana (1982-1999).

Year	Chicken meat (Tons)	Eggs (millions)
1982	175	0.43
1983	259	10.37
1984	590	9.76
1985	922	11.74
1986	1140	13.43
1987	1690	15.55
1988	1768	22.34
1989	2707	37.94
1990	2440	40.32
1991	2597	46.38
1992	5244	61.13
1993	6155	66.41
1994	4605	56.43
1995	7850	56.90
1996	7722	48.13
1997	11847	46.64
1998	15461	59.57
1999	17219	56.49

Source: Annual Report, Poultry Section, Ministry of Agriculture, 1999.

There has been a dramatic increase in per capita consumption of chicken eggs and meat in Botswana, although some reduction in egg consumption has been recorded in recent years (Table 2.2).

Table 2.2. Per capita consumption of chicken eggs and meat in Botswana.

Year	Eggs (No.)	Chicken meat (kg)
1982	2	0.45
1983	11	0.41
1984	12	0.55
1985	11	0.86
1986	12	0.99
1987	14	1.48
1988	23	1.96
1989	32	2.30
1990	38	2.80
1991	36	2.95
1992	45	4.45
1993	47	4.48
1994	38	4.97
1995	39	6.00
1996	33	5.70
1997	31	7.80
1998	38	10.60
1999	35	10.00

Source: Annual Report, Poultry Section, Ministry of Agriculture, 1999.

2.4.2.1 Commercial poultry production in Southern Africa in relation to Botswana

Production and consumption rates of poultry products in Botswana are lower than developed countries and selected Southern African Development Community countries (see Table 2.3) (Mosinyi, 1999). Botswana has a smaller chicken population than other countries in the Southern African Development Community (SADC) countries except for Lesotho, Mauritius and Swaziland (Table 2.3). It should be noted that this data may also include other poultry species as countries often do not separate data into different species (FAO, 1998). The other factor to consider is that the population of chickens will be related to the size of the country. South Africa, the largest country in the region, with its advanced technology leads all other African countries listed.

Table 2.3 Chicken population in the Southern African Development Community region.

Country	Chicken numbers (millions)			
	1989-91	1996	1997	1998
Angola	6	7*	7*	7*
Botswana	2	2*	2*	2*
Lesotho	1	2*	2*	2*
Malawi	12	14	14*	15*
Mauritius	2	3*	3*	3*
Mozambique	22	23*	23*	24*
Namibia	2	2*	2*	2*
South Africa	46	60	59*	59*
Swaziland	1	1	1*	1*
Tanzania	21	25*	26*	27*
Zambia	16	23*	25*	27*
Zimbabwe	12	15*	16*	16*

Source: FAO Production Yearbook (1998).
* = FAO estimates.

Table 2.4. Poultry meat production and total meat production in the Southern African Development Community regional economy.

Country	Poultry meat production (`000 MT)				Meat, total production (`000 MT)			
	1989-91	1996	1997	1998	1989-91	1996	1997	1998
Angola	7	7*	7*	7*	94	99*	103*	102*
Botswana	4	7*	7*	7*	59	67*	70*	64*
Lesotho	1	2*	2*	2*	27	29*	29*	28*
Malawi	40	50*	52*	53*	240	262*	264*	266*
Mauritius	4	4*	4*	4*	62	58	58	58*
Mozambique	27	28*	29*	29*	84	80*	81*	82*
Namibia	2	3*	3*	3*	67	65*	73*	74*
South Africa	372	454*	444*	445*	1328	1229	1232	1422
Swaziland	1	1*	1*	1*	17	19	19	19*
Tanzania	26	32	36	36*	274	299	305	307*
Zambia	19	27*	30*	32*	95	112*	117*	118*
Zimbabwe	17	21*	25*	25*	134	129*	135*	142*

Source: FAO Production Yearbook (1998), * FAO estimates.

The data in Table 2.4 shows that in the SADC region, Swaziland and Lesotho produce the lowest amount of poultry meat followed by Namibia and then Botswana and Mauritius. South Africa is the largest producer in the region (FAO, 1998), but it is important that the production levels be considered in relation to the size and population of each country. Other factors contributing to high production levels in South Africa are likely to be the organised research support system, government support for producers, marketing parastatals and favourable weather conditions for production of feed ingredients and therefore lower input prices (van Rooyen, 2000). Poultry meat in this context includes meat from all domestic birds and refers to ready-to-cook weight (FAO, 1998). The total meat production includes meat from animals slaughtered in the countries irrespective of their origin and comprises horse meat, poultry meat and meat from all other domestic or wild animals such as camels, rabbits, deer and game animals (FAO, 1998).

South Africa has a modern, sophisticated poultry industry with an annual production of 4 400 million eggs and 350 million broilers (Anon, 1996). It is estimated that seven major integrators have a combined weekly throughput of around 6.7 million broiler chicks, although the industry is dominated by Rainbow Chicken Farms, which has a market share of almost 50%. The commercial laying flocks total some 12 million birds, in 500 laying farms. Fourteen of these have flocks of more than 100 000 layers and these account for 60% of the total layer population (Anon, 1996).

2.4.2.2 Broiler production

"National Chicks Botswana" has a hatchery operation, but this does not meet the demand for day-old chicks by broiler producers in the country. Fertile eggs for this operation are imported from South Africa. A total of 17 million hatching eggs are imported annually with an estimated average hatchability of 83%. Broiler chicks are also imported from neighbouring countries (South Africa and Zimbabwe) as day-old birds by private agents.

Published data on the characteristics of broiler farms in Botswana is scanty. Production cycles differ from farm to farm, with small-scale broiler producers having production cycles ranging between 7 and 8 weeks on average. Large-scale producers have shorter cycles of 5-6 weeks. On average birds are slaughtered at 42 days of age (MoA, 1995). Generally, producers are advised to have a two-week resting period for their poultry houses. The recommended stocking density for broilers in Botswana is 10 birds per m^2.

Open-sided sheds are used for both layers and broilers in Botswana. These houses are suitable during most parts of the year because they allow good ventilation. However, problems occur during winter in broiler production systems where heating is necessary. The cost of heating these houses is high especially during the brooding period.

Due to variable management inputs into projects, performance parameters such as growth rate, carcass weight, mortality and feed conversion ratio (FCR) vary substantially. However, the Ministry of Agriculture extension staff use standard values of 10% mortality per batch, daily feed intake per bird of 110g and 1.3 kg carcass weight in project evaluations. The aim is to assist producers to improve their management and to reduce the FCR to profitable levels. However, this has not been easy because the baseline performance data is not available to the extension staff.

2.4.2.3 Egg production

This industry is almost entirely dependent on imported point-of-lay pullets either from South Africa or Zimbabwe. Pullets are purchased at 18 weeks of age and are kept for a period of 10 months in production. Irregularity in the supply of pullets is a problem to many small-scale layer projects resulting in projects either going out of business or restocking with numbers under capacity. The extension staff in the Ministry of Agriculture use standard values of daily feed intake per hen of 120g, hen day production of 75% and hen housed production per hen of 300 eggs for budgeting purposes.

2.4.3 Poultry diseases

Limited information exists on poultry disease monitoring in Botswana. However, Newcastle Disease (NCD), infectious bursal disease (IBD), and egg drop syndrome (EDS) are prevalent in both commercial and back-yard flocks (Adom & Masupu, 1994). Incidence of Newcastle Disease has been recorded throughout the country from 1994 to 1999 (NVL, 1994-1999). Despite this prevalence, there has never been any major outbreak of this disease in the commercial flocks. Other diseases such as fowl pox, fowl typhoid and coccidiosis were recorded in the early 1980s and there is no assurance that they are not prevalent at present, which indicates a serious lack of poultry disease surveillance in the country. According to Mushi *et al.* (1999), few outbreaks of IBD were reported in indigenous back-yard flocks.

2.4.4 Factors limiting poultry production in Botswana

Many factors limit the growth of the poultry industry in Botswana. The major constraints are listed below:

· Lack of quality replacement pullets and day-old chicks

There is only one hatchery in Botswana for the supply of day-old chicks. Most producers buy in birds from either South Africa or Zimbabwe through middlemen. These countries first supply their local demand before they sell any surplus to Botswana. Consequently, the quality of chicks arriving in Botswana is often poor.

· Lack of good quality reasonably priced feeds

Continuous supply of good quality feeds is important if birds are to produce at their genetic potential. Poultry feeds are mostly imported from neighbouring countries and therefore are expensive.

· Lack of veterinary supplies and support

High mortality is a major problem faced by most poultry projects. This is partly due to a poor veterinary support service. Extension agents are not adequately trained in poultry disease diagnosis and control. Moreover, there is only one National Veterinary Laboratory in Botswana catering for the whole country. Disease diagnosis and feedback to producers invariably takes a long time, resulting in the reports being received too late either after a particular batch is sold or most of them have died. In some regions of the country, poultry farms are located in places where medications are not available.

· Lack of skills in poultry production and business

Courses conducted by the Department of Animal Health and Production for poultry producers only last a week and are therefore too short to cover all aspects of poultry production. This results in most producers being under skilled in poultry management as well as business management.

· Shortage of capital

Most small-scale poultry producers do not have enough capital for the purchase of equipment, feed and the building of structures. As a result, poultry projects often fail once Government funding ceases.

· Lack of an organised local market

In beef production, the Botswana Meat Commission takes the responsibility of marketing beef for farmers. The situation is very different in the poultry industry where individual farmers have to do the marketing themselves.

2.5 Concluding comments

With the support from the Government, broiler and layer industries in Botswana have undergone significant expansion during the past two decades. Both industries are currently self-sufficient in terms of meeting the local requirements for chicken meat and eggs, although the layer industry is currently undergoing negative growth. Despite three decades of government input into support programmes, the poultry production systems in Botswana have never been characterised. The present study aims to obtain baseline information on specific aspects of production systems and performance parameters of small-scale commercial poultry operations in Botswana.

CHAPTER 3

A SURVEY OF SMALL-SCALE LAYER PRODUCTION SYSTEMS IN BOTSWANA

3.1 Introduction

Commercial layer operations in Botswana started in the early 1970s. The main source of eggs for the rural population prior to this time was the local Tswana chicken, which was characterised by low production levels (Mosinyi, 1986; Kitalyi, 1997; Mushi *et al.*, 2000). To meet the demand from urban centres and affluent families, eggs were imported mainly from the Republic of South Africa.

The layer industry in Botswana consists of small, medium and large-scale projects. Of these, small-scale projects that are generally funded by Government, are important in terms of both the number of projects and the employment they create. Medium-scale layer projects are either self- or government-funded, while large-scale layer projects are mostly self-funded. The country's main producers of eggs are large-scale operations such as Ace Poultry, Notwane East Poultry Farm, Greenway Farm, Makome Hill Farm and Ladybird Farm. Backyard chickens still remain an important source of eggs in rural areas even though their contribution to the national egg supply is small.

Layer strains used in commercial farms are imported either from South Africa or Zimbabwe; Hy-Line Brown and Lohmann Brown are the most common strains. These strains are characterised by high egg production, better feed efficiency and high liveability. To be successful, it is recognised that a producer needs to start with birds with the genetic potential to lay in the range of 300 eggs over a fifty-week period (Plumstead, 1996). However, in practice choice is limited in Botswana because all birds are imported, the pullets are often in short supply and the producer is forced to purchase what is available irrespective of the quality. Pullets are imported at around 18 weeks of age and they generally start laying at 20 to 22 weeks of age. It is convenient for the farmers, especially small-scale farmers, to purchase point-of-lay pullets because they often lack the facilities and the skill required to rear day-old chicks to point of lay.

Feeds for layer birds are sourced either from South Africa or Zimbabwe. However, there is a local feed milling company (Sefalana) that directly competes with the imported feeds. Layer operations are concentrated on the eastern side of the country leaving the western side with shortages (MoA, 1999). The reason for this high concentration on one side of the country is due to the better transport links for inputs and proximity of market for products. Most urban centres are situated on the eastern side of the country. The country is self-sufficient in egg production, although some imports, were allowed during 1999 from the Republic of South Africa and Namibia to meet local shortages in some parts of the country (MoA, 1999).

Although the Government has actively supported the expansion of the poultry industry under the auspices of FAP for the past two decades, the commercial production systems and productivity indices have never been characterised. Over the years, the Ministry of Agriculture has used several production indices for the budgeting of small-scale layer projects. The national average hen day production is considered to be 75%, and it is assumed that each bird consumes about 120g of layer mash per day with a hen-housed production of 300 eggs (MoA, 1999). How closely these assumed standards compare with actual farm productivity levels is not known. The present study was initiated with the objective of obtaining baseline information on specific aspects of production systems and productivity in small-scale commercial poultry operations in Botswana. It was envisaged that the final outcome would be the identification of both constraints faced by layer producers and areas for possible improvement.

3.2 Research Methodology

A single-visit questionnaire survey was conducted (de Vaus, 1995). The questionnaire incorporated open-ended and closed questions, and was designed to obtain data to meet the objectives of the study. Data collection techniques used included direct questioning and discussions with the producers as well as, where possible, a review of farmer-kept records. In all cases, informal discussions and observations were employed as techniques of verifying collected data. The survey was carried out over a period of three months commencing in January 2001. A list of layer producers was obtained from the Department of Animal Health and Production in the respective areas, and the survey focused only on the small-scale layer producers. For the purpose of this survey, small-scale poultry operations are defined as those valued up to P75 000[2] in terms of fixed assets and flock sizes of less than 2 000 hens. Small-scale projects were selected because these comprise about 80% of the total poultry projects and have a significant employment and income generation role for the rural-based population of Botswana.

The questions in the survey covered demographic details, number of birds kept in the farm, current number of hens, length of the production cycle, number of flocks kept, breeds and their sources, management systems, housing, labour, diseases and their control, hen day production, total eggs produced per bird and feed efficiency, sales and marketing, income, costs of production, Government services and farmer attitude. The questionnaire was pre-tested in two small-scale farms to get an indication of the possible responses. Data from pre-testing were not included in the results. Minor revisions were deemed necessary as the result of pre-testing. The final version of the questionnaire is shown in Appendix I. Before the interviews started, producers were visited by the researcher and informed of the study and its importance.

3.2.1 Location of the study area

The survey covered layer farms in the districts of Francistown and Letlhakane in the eastern part of Botswana (Figure 3.1). These are referred to as districts according to the Department of Animal Health and Production zoning. The locality of these districts provides easy access for inputs as the main North to South road and railway pass on the eastern side. Francistown district has a land area of approximately 57 600 km^2 and has an estimated population of 143 400. Letlhakane district has a land area of approximately 31 650 km^2 and a population of 42 670 (Central Statistics Office, 1997).

[2] \$0.1788 US = P1.00 (October 04, 2001).

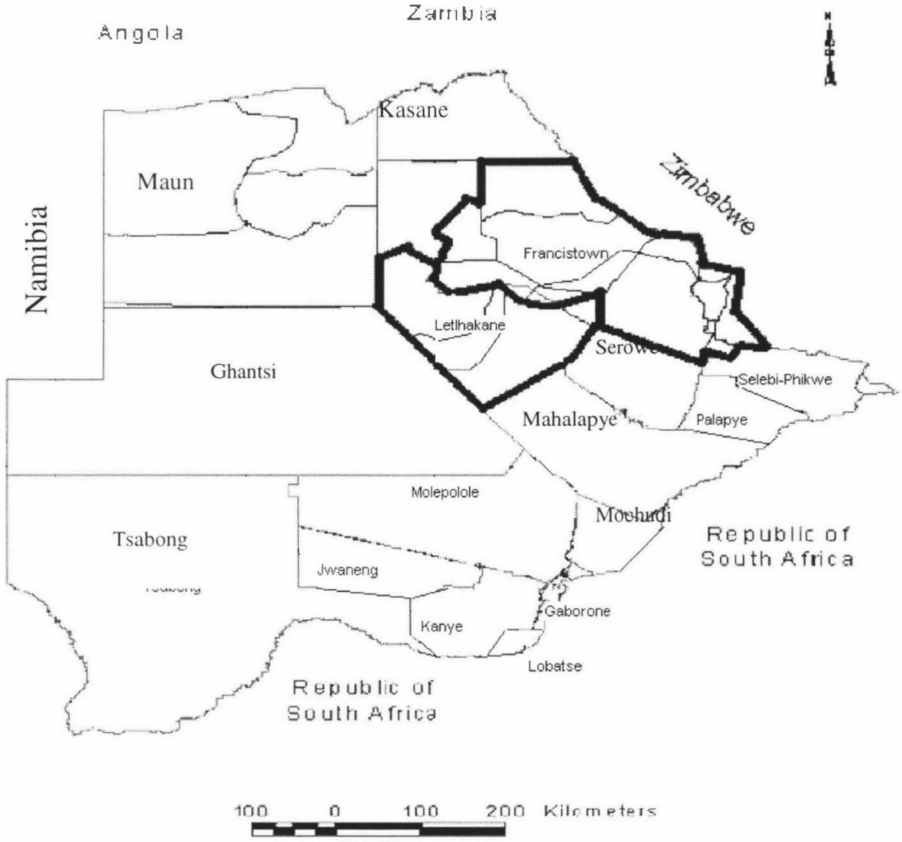

Figure 3.1 A map of Botswana showing the study areas (shown by bold outlines).

3.2.2 Data analysis

After the survey, the questionnaires were collated at Massey University for analysis. Data were sorted and coded before being analysed. Data were analysed using SPSS 10.0 for Windows (2000) to calculate frequency of distribution and to examine correlations between production parameters. Hen-day production and feed conversion ratio were calculated. Percentage hen day production was calculated by dividing the number of eggs produced for the particular day by the average number of hens and then converting to a percentage. Number of hens in a farm was calculated by averaging total number of hens at the start of the month of study and at the end of the month. Feed conversion ratio was calculated by dividing the total feed intake of the flock by the total number of eggs produced per year.

3.3 Results

Questionnaires were given to 17 farmers. A total of 14 or 82% of the questionnaires were returned.

3.3.1 Age profile of producers

The age profile of the producers is shown in Table 3.1. Only two people (13.3%) were less than 30 years of age. The age ranges of 31-40 and 41-50 years had equal numbers of producers with 33.3% each. Three producers (20%) were above 50 years of age.

Table 3.1 Age profile of egg producers in the two districts surveyed.

Age in years	Number	Percentage
<30	2	14.3
31-40	5	35.7
41-50	4	28.6
>50	3	21.4

3.3.2 Gender profile of producers

Of the total 14 projects, nine projects were owned by women (Table 3.2).

Table 3.2 Gender profile of egg producers in the two districts surveyed.

Characteristics	Frequency	Percentage
Male	5	35.7
Female	9	64.3
Total	14	100

3.3.3 Education status of producers

Four categories were used to describe education status. The categories used were primary level, secondary, tertiary and other. The results showed that five producers (35.7%) had completed primary education only; eight (57.1%) did their secondary education while one (7.1%) had tertiary qualifications.

3.3.4 Housing

All (100%) farms used open sided houses with bird mesh on the sides. The houses are built facing an east-westerly direction to prevent direct sunshine entering the shed in the mornings and in the late afternoons. The open sided houses with a ridge at the top allowed good ventilation. The houses or sheds had a concrete floor, brick walls with 1m high sidewalls. Above the brick sidewalls, mesh wire stretched up to the roof level. The roof was mainly corrugated iron. The height of the house is on average 3m in the centre and 2m on the sides allowing for an overhang, which provided shelter from rain. One producer had sidewalls made of corrugated iron, with mesh wire extending to the roof level.

All producers used cage systems for their layer birds. On average four birds were housed per cage. The types of cages used were traditional two-tier cages with a total area of 1800 cm^2 per cage, with an area space of 450 cm^2 per bird.

3.3.5 Layer strains used and their sources

The main strains used for egg production are Lohmann Brown (64.3%) and Hy-Line Brown (35.7%). All producers (100%) purchased their point-of-lay pullets through local agents. Pullets (18 weeks old) were sourced from either South Africa or Zimbabwe.

3.3.6 Number of layers per farm

Flock sizes in individual farms differed markedly (Table 3.3). The minimum number of hens per farm was 189 while the maximum was 995. Eight farms (57.1%) had flocks of over 500 layers. The average flock size was 541.2 ± 237 layers.

3.3.7 Production parameters

3.3.7.1 Hen day production

Eggs were collected twice daily in the morning and afternoon. The average hen day production was calculated to be 71.7 ± 12.9% (Table 3.3). During the course of the year, one farm (Farm 4) experienced severe feed shortages, resulting in a marked decline in egg production. There was a significant ($P=0.03$; $R^2 = 0.92$) positive correlation between feed intake per day and eggs produced per day, indicating that hen-day production was strongly influenced by feed intake.

3.3.7.2 Eggs per bird per production cycle (22 weeks to culling)

Production cycle refers to the period from the start of lay (22 weeks of age) to culling. All producers culled the birds when the egg production started to decline. Culling usually started after 10 months of production. However, in some cases the culling was dictated by the availability of replacement stock. On average each bird produced a total of 245 ± 22.5 eggs per production cycle (Table 3.3).

3.3.7.3 Feed intake per bird

Data showed considerable variation in daily feed intake per bird (101-120g) from week 18 of age to culling (Table 3.3 and Figure 3.2). The average daily feed intake was 108.0 ± 6.49 grams. On average each bird consumed 35.6 ± 2.1 kg during the period from 18 weeks of age to culling. The observed variability appears to be influenced by factors such as ambient temperature, management, water availability and temperature of the water. There was a strong positive correlation ($P < 0.01$; $R^2 = 0.95$) between feed intake per flock and eggs produced per flock, showing that egg production is dependent of adequate feed supply.

Table 3.3 Average production parameters in the small-scale layer farms in Botswana

Farm No.	Flock size	Hen day production (%)	Eggs per bird	Feed per bird per day (g)	Feed per dozen eggs (kg)	Mortality per flock (%)
1	995	80.0	264	109.6	1.64	1.0
2	500	68.3	226	109.1	1.91	8.6
3	500	76.0	251	103.0	1.63	8.0
4	460	34.0	216	112.0	2.06	6.6
5	600	68.0	224	110.0	1.95	0.8
6	498	80.3	265	100.4	1.50	12.0
7	292	65.0	215	104.8	1.93	10.6
8	473	74.0	244	110.0	1.78	10.0
9	500	71.0	233	100.0	1.70	6.3
10	300	81.0	267	120.0	1.78	2.3
11	189	75.1	248	120.0	1.92	33.0
12	500	72.0	238	109.1	1.82	7.0
13	990	76.0	250	101.0	1.60	6.0
14	780	70.3	295	103.0	1.40	6.3
Mean ± SD	541.2 ± 237	71.7 ± 12.9	245 ± 23	108.0 ± 6.5	1.75 ± 0.19	8.46 ± 7.8

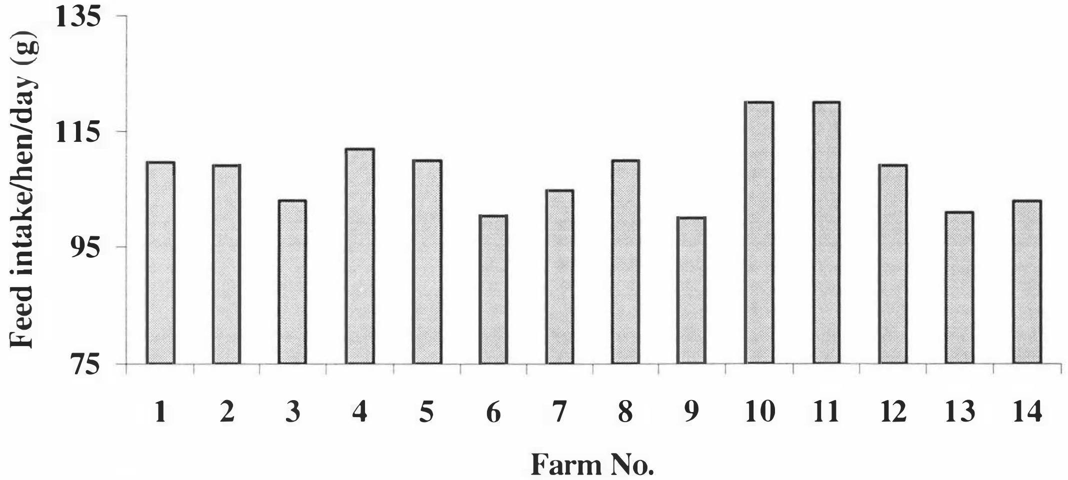

Figure 3.2 Average daily feed intake per bird in the 14 layer farms surveyed

3.3.7.4 Feed conversion ratio

On average, 1.75 ± 0.19 kg of feed was required to produce a dozen eggs (Table 3.3), but considerable variation (1.40 to 1.95) was noted across the farms (Figure 3.3). A slight positive relationship ($P = 0.03$; $R^2 = 0.34$) was detected between the feed intake per bird and the feed required to produce a dozen eggs.

3.3.7.5 Average mortality per flock

There was wide variation in mortality between the farms (Table 3.3), with values ranging from 1.0 to 12.0%. The average mortality (18 weeks of age to culling) per flock was 8.46 ± 7.81%. Diseases or conditions reportedly associated with these deaths included Newcastle disease, prolapse of the uterus and diarrhoea. Diarrhoea may include symptoms of infectious diseases such as salmonellosis, Newcastle Disease, fowl cholera and fowl typhoid. Despite this, none of the producers vaccinated their birds.

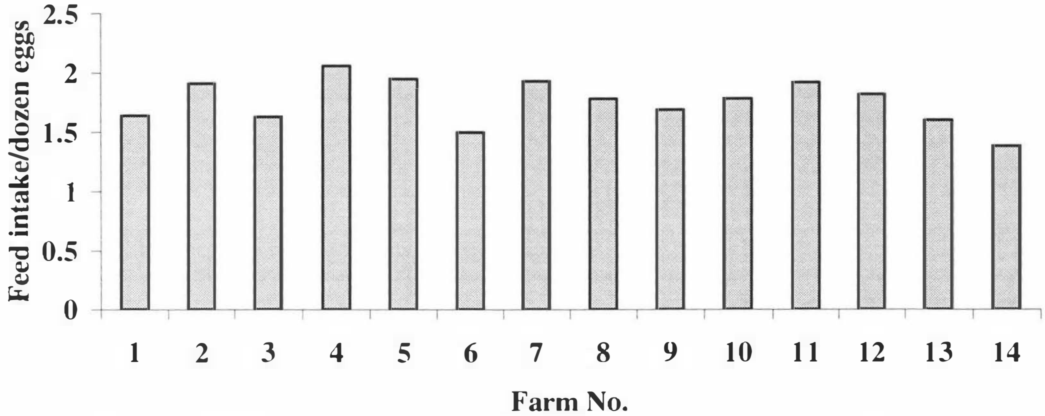

Figure 3.3 Feed conversion ratio (kg feed/dozen eggs) of the 14 farms surveyed

3.3.7.6 General management

3.3.7.6.1 Feeds and sources

Information on the type of feeds used in the layer farms was also obtained. Of the fourteen farms surveyed, ten (71.4%) used medium energy layer mash, while two (14.3%) used only high energy layer mash, the remaining two (14.3%) producers used both medium and high energy layer mash for their hens. Medium energy layer mash has an energy concentration of 11.5 MJ/kg (2 750 Kcal/kg) and a crude protein content of 16.5% while high-energy layer mash has an energy concentration of 11.9 MJ/kg (2 850 Kcal/kg) and a crude protein content of 17.0%. These feeds are sourced from Agents who either import from South Africa or Zimbabwe or purchase from the local feed milling company. None of the farms provided extra calcium sources during the production cycle.

3.3.7.6.2 Farm labour

One farm (7.1%) used family labour only, while three farms (21.4%) used hired labour only. Over half of the farms (71.4%) used both family and hired labour. Of all the labour in the farms surveyed, 78.6% was female labour and the remaining was male labour. Four farms (28.6%), used children as part of their labour force, but usually during the school holidays. In general, farms with small flock sizes tended to use more family labour while farms with larger flock sizes used more hired labour.

3.4 Discussion

The age profile of the producers showed that only a small percentage of them were below the age of 30 years. The low number of producers below 30 years of age probably reflects costs associated with the production system itself. All layer farms used cages, which are costly and require high investment. Clearly young people would not have the necessary capital to start the projects or contribute towards the government grant. This finding provides some evidence that lack of credit is a major constraint to the growth of the poultry industry in Botswana. Credit for poultry farming is not readily available in Botswana because commercial banks consider poultry farming a risky venture.

Under the FAP, the Botswana Government has actively encouraged the involvement of women in business (MFDP, 1995). This policy stipulates that women are to be granted 15% of the total cost of the project while men receive no weighting. Therefore, it was not surprising to find that, in the two districts studied, 64.3% of the layer projects are female owned.

All farms surveyed used cages to house their birds. Although this system is expensive, it has advantages over other systems with simpler management, cleaner eggs, improved feed conversion as a result of reduced feed wastage, and reduced parasite load and mortality. The cages used in Botswana are imported either from South Africa or Zimbabwe. The high costs associated with the cage system reflect this importation factor and unless the government intervenes there is little hope for the small-scale producer. The types of cages used are traditional two-tier cages with a total area of 1800 cm^2 per cage, with a space area of 450 cm^2 per bird.

Education and training need to play a crucial role in poultry production if better returns are to be realised. Knowledge of differences between critical inputs and of proper record keeping are especially vital. Almost half the producers (42.9%) attended a one-week poultry production course organised by the Department of Animal Health and Production. However, it should be reported that record keeping of the egg producers interviewed was inaccurate and did not reflect any benefit of the extension course offered. This may be a reflection of lack of follow-up made after the courses due to lack of facilities by the poultry extension workers. It is therefore imperative that there should be an evaluation of the success rate of these courses.

The type of houses used within a given environment influences productivity of the hens. Open sided brick walled houses are used in Botswana. Different authors investigated hen performance in tropical climates under this type of housing system (Hargreave, 1982; Al-Rawi & Abou-Ashour, 1983; Koekelbeck & Cain, 1984; Mohammed & Mohammed, 1991; Chabo *et al*., 2000) and reported high egg production under the open house and cage systems compared to closed houses and floor system. In general, egg production and daily feed intake reported in these studies were comparable to those found in this survey in Botswana.

This study showed that the average hen day production in small-scale farms was 71.7%. However, the Ministry of Agriculture uses an average hen day production of 75% for budgeting purposes. Many factors are known to affect hen day production and these include dietary nutrient levels, ambient temperature and type of housing system (cages versus floor or slats) (Stockland & Blaylock, 1974; Hargreave, 1982; Al-Rawi & Abou-Ashour, 1983; Al-Awadi *et al*., 1995). The nutrient content of the diet, especially protein content during rearing, plays an important role in the laying performance of the pullet. Since local farms source point-of-lay pullets from neighbouring countries, the rearing background of these pullets was unknown. The hen day production (71.7%) recorded in this study is lower than breed standards, and may be associated with the way these birds were raised during pre-lay especially the protein content of their diets (Stockland & Blaylock, 1974). According to Stockland and Blaylock (1974), showed that feeding pullets a 16-12-12% protein level in diets from 6 weeks of age to 20 weeks resulted in maximum weight and efficiency of feed utilization at 20 weeks, reduced the number of days required to reach 50% egg production and improved subsequent performance during the laying cycle, when compared to lower protein levels (14-12-12%). Ideally, egg producers should seek records on the level of management given to their pullets before they are sold. This will be hard though as the producers have little choice due to the scarcity of replacement pullets in the country (Mosinyi, 1999).

It is generally considered that birds tend to adjust feed consumption to meet energy needs, but this is not always done precisely enough to ensure optimum growth and performance (Hy-Line Brown Variety management guide, 2000-2001). It appears that the lower hen day production recorded in this study may be partly due to reduced energy intake by hens due to the lower energy feeds used in Botswana (Al-Rawi & Abou-Ashour, 1983; Al-Awadi *et al*., 1995).

Data presented in this study showed a positive relationship between feed intake and egg production. This is in agreement with previous work that showed that feed intake determined egg production (Al-Rawi & Abou-Ashour, 1983) provided environmental temperature and other factors were not limiting. It is important therefore, that producer training should highlight the importance of proper feeding and its implications. This should be carried out however, without forgetting that feed costs take up about 70-80% of the total cost of poultry operations.

In the two districts surveyed, the summers are hot with temperatures reaching 35 ^{0}C, which will have a direct effect on layer performance. Though there was no direct evidence from the survey to show that lower hen day production was related to the high ambient temperature, it appears that this may have played a part. Indirect evidence comes from the positive correlation observed between feed intake and number of eggs produced. Hargreave (1982) and David (1982) stated that when feed intake falls due to high temperature, nutrient supply may not be sufficient to maintain egg yield and will result in either reduced production, reduced egg size, or both. The use of high-energy diets will help maintain production and egg size when environmental temperatures are high. The study of Hargreave (1982) showed that feed consumption declines at the rate of 1.6% for each 1 ^{0}C rise in temperature between –5 ^{0}C and 30 ^{0}C. David (1982) reported that each 1 ^{0}C drop in temperature below 21 ^{0}C can reduce egg production by 0.5% and increase feed consumption by 1.5% and each 1 ^{0}C rise in temperature between 25 ^{0}C and 30 ^{0}C can reduce egg production by 1.5%, reduce feed consumption by 1.5% and reduce egg size by 0.3g per egg. Above 30 ^{0}C production and feed consumption declines rapidly. Stockland and Blaylock (1974) also showed that under elevated temperatures, feed intake and egg production are depressed.

Al-Rawi and Abou-Ashour (1983) compared feed intake of caged pullets placed in a closed house and those placed in an open sided house. Pullets in the closed house consumed significantly more feed than those in an open house (120.1g versus 109.1g per day). The average intake in the open houses was similar to that observed in the present study (108.0g per day). In contrast, an experiment by Chabo *et al.* (2000) in Botswana, showed that daily feed intake per hen was 118g when hens were housed in an open sided, corrugated iron roofed house. This value is higher than the average intake of 108g found in the current study. However, these authors used a smaller sample size and their study was carried out in the Southeastern part of the country where the summer is relatively milder.

All producers culled their hens when hen day production started to decline below 50%. This typically happened after 52 weeks in production (around 74-78 weeks of age). Under optimum conditions, modern layers produce 300 or more eggs per production cycle (Hy-Line Variety Brown, 2000-2001). The lower production levels recorded in the present study (245 eggs) suggest that there is potential for further improvement. Detailed studies are needed to examine the underlying causes of the lower production levels in Botswana.

The most important parameter in layers, which dictates profitability, is the amount of feed used to produce a dozen eggs. In the present study 1 750g of feed was required to produce one dozen eggs. This efficiency level is better than the value of 1 953g reported by Al-Rawi & Abou-Ashour (1983) for layers housed in an open sided house in Saudi Arabia and the value of 2 710g reported by Al-Awadi *et al.* (1995) in caged layers in Kuwait. However, the Botswana value is higher than the recommendation by the breeder company that a hen should consume an average of 1 580g of feed to produce one dozen of eggs (Hy-Line Variety Brown, 2000-2001).

Pullets are expected to have had all the necessary vaccinations prior to 18 weeks of age. In this study none of the producers vaccinated their flocks. According to the National

Veterinary Laboratory reports (1990-1999), Newcastle disease has not been a problem in commercial flocks. This suggests that the vaccination programmes by the pullet rearing companies in South Africa and Zimbabwe are carried out correctly. The data from the present study showed that mortality from 18 weeks of age to culling was 8.46%. This is useful data for use in budgeting to project the number of pullets required to sustain a given number flock size in a farm.

In this study Lohman Brown and Hy-Line Brown were the only strains of layers used. There is no exact reason for the preference of these strains, except for the fact that these are the only available breeds in the market. Moulting of birds is not practised in layer farms in Botswana. There is no explanation for this, but it may be associated with loss of production and market during the times when birds are moulting.

The aim of Botswana Government policies has been to create employment for the local citizens. It is therefore not surprising to find that farm operations on most small farms rely heavily on family labour. Family labour formed the major part of the labour personnel in small-scale layer projects because producers who own these projects were mostly previously unemployed. Women play an important role in the management of small poultry farms. Large portion of operators are women, and additionally farms also use female family labour.

Even though some information on income and expenditure was obtained, the cost of production was not easy to calculate, as over half of the small-scale egg producers did not indicate costs related to their production systems. This is a clear indication that accurate record keeping is a problem and needs to be addressed by poultry extension staff. The profitability and viability of a poultry enterprise is influenced by a number of factors, the most important ones being feed costs and market prices. To operate an efficient operation, the producer needs to maintain proper production and financial records.

3.5 Conclusions

The aim of the present study was to obtain baseline information on specific aspects of production systems and productivity in small-scale layer farms in Botswana. The average hen day production for small-scale layer farms was 71.7%. The small-scale layer farms in Botswana cull their hens after 52 weeks in production (78 weeks of age) during which time each hen produces 245 eggs. The average feed intake for small-scale layer farms was 108g per bird per day and 1 750g of feed is required to produce a dozen of eggs. The average mortality from 18 weeks of age to culling was 8.46%. There is no comparable data available in Botswana. To my knowledge, this is the first study carried out in commercial layer farms. For budgeting purposes, the Ministry of Agriculture extension staff, however, has been using an average hen day production of 75%, with an assumption that each bird produced 300 or more eggs per production cycle, and feed intake of 120g per hen per day. The data from this study show therefore that extension staff are overestimating hen day production and eggs per production and underestimate feed intakes. This suggests major errors occur in budgeting.

Generally, the survey showed poor performance levels in layer farms in Botswana. Factors contributing to this poor performance are complex, but management skills, feed supply and quality and pullet quality are identified as immediate areas for improvement.

CHAPTER 4

A SURVEY OF SMALL-SCALE BROILER PRODUCTION SYSTEMS IN BOTSWANA

4.1 Introduction

Commercial broiler production started at almost the same time as commercial egg production in Botswana. Prior to the 1970s, the meat source for the rural population was the local Tswana chicken. However, the local Tswana chicken is associated with low production levels, low growth rates and poor feed conversion efficiency (Mosinyi, 1986; Kitalyi, 1997; Mushi *et al*., 2000). The age at marketing of local meat birds is more than 24 weeks compared to less than 8 weeks for commercial broiler birds (Kitalyi, 1997).

Botswana National Chicks, a privately owned hatchery, supply day-old broiler chicks in the country, but hatching eggs for this hatchery are imported from South Africa. Since the local supply is unable to meet the demand of day-old chicks in the country, the balance is imported from South Africa and Zimbabwe through private agents (MoA, 1999). As a result, it is difficult for producers to control the quality of chicks that are purchased. Disease is also a potential problem because imported chicks may harbour egg-transmitted diseases such as salmonella. Compared to small-scale layer projects, there are large numbers of small-scale commercial broiler projects. This is probably because a broiler production cycle takes less time (eight weeks) than egg production (10 months) and therefore offers quicker returns on investment. The total investment in housing and equipment is also lower in broiler production since the birds are reared on the floor.

For budgeting purposes, the Ministry of Agriculture uses a standard feed intake value of 110g per bird per day (MoA, 1999). No information is available on the average slaughter weight of broilers in Botswana except that marketing age and weight are determined by market demand. Broiler birds are kept for a longer period than normal, as consumers demand a bigger product. For budgeting purposes, a standard production cycle is assumed to be between six and eight weeks with an average dressed carcass weight of 1.3kg (MoA, 1999). There is no specialised poultry abattoir in the country, but some producers own small slaughter facilities. Most small-scale projects slaughter and dress the birds within the farm location.

The objective of the present study was to obtain baseline information on specific aspects of production systems and productivity in small-scale commercial broiler operations. It was envisaged that the final outcome will identify the major constraints faced by broiler producers and areas for possible improvement.

4.2 Research Methodology

A single-visit questionnaire survey was conducted. The questionnaire incorporated open-ended and closed questions, and was designed to obtain data to meet the objectives of the study. Data collection techniques used included direct questioning and discussions with the producers as well as, where possible, a review of farmer-kept records. In all cases, informal discussions and observations were employed as techniques of verifying collected data. The survey was conducted in the Francistown and Letlhakane districts during a 3-month period commencing from January 2001. A list of small-scale broiler producers in the respective areas was obtained from the Department of Animal Health and Production. These two districts were selected because they offered a larger number of small-scale projects to be studied. The aim was to survey all small-scale commercial broiler farms in these districts. Of the 100 farmers contacted, only 59 responded. For the purpose of this study, small-scale poultry operations are defined as those valued up to P75 000[3] in terms of fixed assets with batch sizes ranging between 500 and 2000 birds. Small-scale projects were selected in the present study because these comprise about 80% of the total poultry projects and have significant socio-economic implications for the population of Botswana, especially the rural based majority.

The questions in the survey covered demographic details, number of batches per year, current batch size, length of the production cycle, number of batches kept, strains and their sources, management systems, housing, labour, diseases and their control,

[3] \$0.1788 US = P1.00 (October 04, 2001)

production parameters, sales and marketing, income, costs of production, government services and farmer attitude. The questionnaire was pre-tested with two small-scale broiler producers to get an indication of possible responses. Data from the pre-testing are not included in the results. Minor revisions were deemed necessary as a result of pre-testing. The final version of the questionnaire is presented in Appendix II. Before the interviews started, producers were informed of the study and its importance.

4.2.1 Location of the study area

Details of the study area are discussed in Section 3.2.1 and the locations of Francistown and Letlhakane districts are shown in Figure 3.1.

4.2.2 Data analysis

Data were analysed as previously discussed in Section 3.2.2. Feed conversion ratio was calculated by dividing the total feed used for a batch of broilers by total kilograms of live weight sold.

4.3 Results

A total of 100 questionnaires were delivered, but only 59 were returned, corresponding to a 59% response rate.

4.3.1 Age profile of producers

The age profile of the producers is shown in Table 4.1. Only seven producers (11.9%) were less than 30 years of age. The age range of 31-40 and those above 50 years had equal numbers of producers with 27.1% each. Twenty producers (33.9%) were in the age range 41-50.

Table 4.1. Age profile of producers in the two districts surveyed.

Age (years)	Number	Percentage
<30	7	11.9
31-40	16	27.1
41-50	20	33.9
>50	16	27.1

4.3.2 Gender profile of producers

Of the total 59 projects studied in the two districts, 41 projects belonged to women while 17 projects belonged to men. The remaining project belonged to a group of both males and females.

4.3.3 Education status of producers

Four categories were used to describe educational status. The categories used were primary level, secondary, tertiary and other. The results showed that 18 producers (30.5%) had completed only primary education, 27 (45.8%) completed their secondary education while 11 (18.6%) had tertiary qualifications and three (5.1%) producers had other qualifications.

The Department of Animal Health and Production provides a 1-week training course for producers on various aspects of broiler production including record keeping, diseases, feeding, general hygiene, brooding and marketing strategies. A total of 38 broiler producers (64.4%) had attended the training course. Three producers (5.1%) had a Diploma in Agriculture or related qualifications and the remaining 17 (28.8%) had no specialised training in poultry production.

4.3.4 Housing

Broiler houses were similar to those used in layer farms and details are given in Section 3.3.4. It was observed that about 20% of poultry houses in the Francistown district were flat roofed, while in Letlhakane district all houses had a ridge at the top. The houses with a ridge at the top had superior ventilation.

4.3.5 Broiler strains used

The majority (72.9%) of the broiler producers used Cobb strain. About (27.1%) used other strains, amongst them Ross strain was common. The day-old broiler chicks were sourced from National Chicks or from South Africa and Zimbabwe through private agents. 'National Chicks', the only privately-owned hatchery in Botswana, does not meet local demand so that day-old chicks have to be imported to cover the shortfall.

4.3.6 Number of birds per production cycle

Numbers of broilers per production cycle in small-scale operations ranged from 100 to 2000 birds, with an average of 640 birds (Table 4.2). Bigger farms had several sheds, which enabled production to be continuous. Small farms housed less than 500 birds per shed while bigger farms had an average of 2000 birds per shed. The stocking density was 10 birds per m^2. The number of birds per production cycle depended largely on the market demand for broiler meat. Producers with better marketing skills were able to sell more and stock large numbers.

Table 4.2 Number of broilers per production cycle (batch) in small-scale broiler farms.

Number of birds	Number of farms	Percentage
<100	3	5.1
101-200	2	3.4
201-300	5	8.5
301-400	7	11.8
401-500	13	22.0
501-600	7	11.8
601-700	5	8.5
701-800	5	8.5
801-900	0	0
901-1000	0	0
>1000	12	20.4

4.3.7 Production cycles per annum

The number of batches of broilers reared on a farm varied according to a number of factors, including availability of finance, availability of day-old chicks, feeds and markets. The number of production cycles per annum was also dictated by the interval between batches of broilers, cleaning and resting of the sheds. Considerable variation was observed between the farms in the number of production cycles per annum. Two farms (3.4%) had only one production cycle, seven farms (11.9%) had three and 16 farms (27.1%) had four. Thirty farms (50.8%) had five production cycles and only two (3.4%) had six production cycles per annum. The average number of production cycles per annum for small-scale broiler farms was 4.37 ± 0.99.

The interval between broiler batches was also investigated. Twenty-eight farms (47.5%) had a two-week interval, 18 farms (30.5%) had a three-week interval, 12 farms (20.3%) had a four-week interval and one (1.7%) had a five-week interval between broiler batches. The average interval between batches in small-scale broiler farms was 1.76 ± 0.84 weeks.

4.3.8 Performance parameters

Performance parameters are shown in Table 4.3. The average slaughter age of broilers was estimated to be 48.3 days, the average weight at slaughter being 1794g while the average carcass weight was 1 418g. The average daily feed intake per bird for small-scale broiler farms was 91.10g and the FCR was 2.72 kg feed/kg live weight.

Table 4.3 Performance parameters of broilers in small-scale farms in Botswana.

Characteristic	Mean	Min.	Max.
Age at slaughter (days)	48.3 ± 0.87	35	70
Weight at slaughter (g)	1794 ± 0.39	1200	2500
Carcass weight (g)	1418 ± 0.31	900	2200
Feed/bird (g)	4460 ± 115	3000	8330
Feed intake/bird/day (g)	91.1 ± 23.5	57.8	170.1
FCR (kg feed/kg live weight)	2.72 ± 0.94	1.63	5.56

It should be noted, however, that some producers did not keep good records. It also appeared that some of the producers, who had attended the departmental training course, used the standard values given during the course to complete the questionnaire.

Interestingly, significant correlations were only observed between some of the production parameters in this study (Table 4.4). The correlation between live weight at slaughter and feed conversion ratio (FCR) was negative (P=0.0001; R^2 = -0.37), indicating that as broilers grow heavier they used more feed to produce a kilogram of live weight. However, the lack of correlation between the other parameters (e.g. age versus slaughter weight; age versus FCR) was unexpected and probably reflects poor record keeping, rather than the actual situation.

Table 4.4 Correlations between age at slaughter, slaughter weight, carcass weight, feed per bird and feed conversion ratio (FCR).

	Age	Slaughter weight	Carcass weight	Feed/bird	FCR
Age	-	0.0002	0.0001	0.0003	0.0004
Slaughter weight	0.0002	-	0.77**	-0.000002	-0.37**
Carcass weight	0.0002	0.77**	-	-0.000002	-0.31**
Feed/ bird	0.0003	-0.000002	0.000002	-	0.51**
FCR	0.0004	-0.37**	-0.31**	0.51**	-

**P<0.01

4.3.9 General management

4.3.9.1 Brooding

Proper brooding and the provision of warmth to young chicks is necessary to realise better returns. A total of 44 (74.5%) producers used gas brooders for heating, 6 (10.2%) used coal for heating, while 9 (15.3%) used other sources of heat (paraffin and wood). No heating was provided during summer when temperatures are high. However, a large diurnal fluctuation in temperature may warrant heating of the shed during the night.

4.3.9.2 Bedding material

Sawdust was the most popular bedding material (55.9%), followed by wood shavings (35.6%). The remaining producers (8.5%) used other types of bedding such as paper, grass and sorghum bran. The higher use of sawdust is due to the fact that the majority of small-scale broiler projects are located in rural areas where it is difficult to obtain wood shavings. Sawdust is usually sourced from local carpenters.

4.3.9.3 Types of feeds

Feed was purchased from local agents who either import it from Zimbabwe and South Africa or purchase it from the local feed milling company. Birds were fed broiler starter diets for the first three weeks (1-21 days) and finisher diets during the remainder of the growth period (22-49 days). Broiler starter diets had an energy concentration of 13.0 MJ/kg (3000 Kcal/kg) and a crude protein content of 22.0% while broiler finisher diets had an energy concentration of 13.4 MJ/kg (3200 Kcal/kg) and a crude protein content of 20.0%. In addition to broiler starter and finisher, twenty farms (n=20) also provided broiler grower (day 14-21) and post finisher (49 days to slaughter) diets.

4.3.9.4 Diseases and mortality

Poultry diseases reported in the broiler farms are summarised in Table 4.5. A total of 25 farms (42.4%) recorded Newcastle Disease and a further 7 (11.9%) recorded infectious bursal disease. Other diseases reported included diarrhoea 6 (10.2%), which may be a symptom of diseases such as salmonellosis, fowl typhoid, Newcastle Disease etc., paralysis of the limbs 5 (8.5%), chronic respiratory disease 3 (5.1%) and coccidiosis 2 (3.4%). Eleven of the 59 farms surveyed reported no major disease problems. The majority of the producers (69.5%; n=41) vaccinated the birds for Newcastle disease while 16 (27.1%) did not practice any vaccination. A total of 53 (89.8%) of broiler producers used disinfectants for hygiene purposes and the remaining 6 (10.2%) had never used any disinfectants on their farms.

Table 4.5 Poultry diseases reported in small-scale broiler farms.

Disease	Number of farms	Percentage
Newcastle disease	25	42.4
Infectious bursal disease	7	11.9
Diarrhoea	6	10.2
Paralysis of the limbs	5	8.5
Chronic respiratory disease	3	5.1
Coccidiosis	2	3.4

The average mortality per batch was 9.15 ± 0.96%. The minimum mortality reported per batch was 2.0% and the maximum was 35%.

4.3.9.5 Farm labour profile

The type of labour used in the farms is shown in Table 4.6. A total of 7 farms (11.9%) used family labour only. Nineteen farms (32.2%) used hired labour only. Over half of the farms (55.9%) used both family and hired labour. Of all the labour in the farms surveyed, 73.4% was female labour and the remaining 26.6% was male labour. Some farms used child labour, but usually only during the school holidays. In general, farms with small batch sizes (200-500 birds) used only the family labour while farms with bigger batch sizes (700-2000 birds) used only hired labour.

Table 4.6 Distribution of labour among the farms surveyed.

Characteristic	Percentage	Minimum (%)	Maximum (%)
Family labour	11.9	0	100
Hired	32.2	0	100
Both family and hired	55.9	20	95

4.3.9.6 Attitudes and general comments by producers

4.3.9.6.1 Farmer attitudes

Farmer perception on the long-term viability of small poultry farms was mixed. Most producers were optimistic about the future of poultry production in Botswana. Some felt that if the Government could intervene by subsidising poultry inputs, they could expand the farms and even export poultry products. Some producers, however, saw the future in poultry production as bleak, due to a lack of protection of small-scale producers from large poultry enterprises operating in urban areas with access to cheap imported inputs.

4.3.9.6.2 General comments

Both small-scale broiler and layer producers felt that the Government should intervene to control feed prices because high feed prices were identified as the major cause of farm closures. It was suggested that the Government should subsidise poultry feeds, as in the case with cattle feeds. Poor marketing skills and poor facilities are other reasons leading to the collapse of small-scale projects. Producers felt that there should be an organised marketing structure like Botswana Meat Commission for poultry products. Some small-scale producers also felt that the extension officers should not allow the establishment of too many projects in one locality, as they would compete for the same consumer base.

Interestingly, Government policies have also encouraged the establishment of poultry farms in some institutions like schools, and these institutions often compete with small-scale producers for the same customer. But Government subsidisation of these institutions leads to prices of produce, which are not a true reflection of their cost of production. It was felt that if these projects in schools are meant to teach students they either should be small, or students should be attached to small-scale farms during the holidays as part of their curriculum.

Producers indicated lack of finance as another major cause of failure or lack of progress in their endeavour to succeed. Therefore, they felt that government grants should be increased to counter the escalating prices of feeds and equipment.

4.4 Discussion

The primary aim of the present study was to obtain baseline information on specific aspects of production systems and productivity in small-scale broiler farms in Botswana. Age profiles of producers showed that only a small percentage were below the age of 30 years. The low number of producers below 30 years of age probably reflects costs associated with the production system itself. All broiler farms used gas for brooding, which is associated with high costs. Clearly, young people do not have the necessary capital to start the projects or contribute towards the government grant. This finding emphasises that lack of credit is a potentially major constraint to the growth of the poultry industry in Botswana. Credit for poultry farming is not readily available in Botswana because commercial banks consider poultry farming too risky.

Under the FAP, the Botswana government has given women an advantage over men to encourage their involvement in business (MFDP, 1995). This policy stipulates that women are granted 15% of the total cost of the project as a gender factor while men receive no weightage. It is therefore not surprising to find that 69.5% of the broiler projects are female-owned.

Farmer training, especially knowledge of the differences between critical inputs and proper record keeping, are crucial factors if better returns are to be realised. Over half the producers (64.4%) attended a one-week training course on poultry production conducted by the Department of Animal Health and Production. It was observed, during the survey, that level of record keeping by small-scale farmers did not reflect this attendance of the course. It is therefore imperative that there should be an evaluation of the success rate of these courses.

All poultry houses used by small-scale producers were open sided with concrete floors and corrugated roofs. Producers in the Francistown District with lower batch numbers (< 500 birds) had flat roofed houses. When houses are small and the density of birds per house is low, flat roofed houses are preferred because they are relatively cheap to construct compared to ridged houses (Plumstead, 1996). Flat-roofed houses are also easier to heat than ridged houses where heat will escape from the top vent. The main source of heating for brooding of broiler chicks was gas heating provided by spot heaters. Gas is expensive in Botswana and this increases the cost of production.

Small-scale producers generally keep broiler numbers that are easy to sell within a given time. The number that can be sold is related to market demand in the area and the marketing skills of individual producers. Some producers indicated that the government should not allow the establishment of more than two projects in smaller locations as producers end up competing for the same market. It was also suggested that the training course offered to the producers should be structured to improve knowledge on business skills and marketing strategies.

Employment creation had always been the primary focus of the Botswana government policies. It is therefore not surprising to find that family labour is involved in all small-scale projects. Family provides most of the labour in small-scale broiler projects because producers who own these projects are almost always previously unemployed and this is consistent with the government policy that encourages owner-operated projects (MFDP, 1995). In general, farms with small batch sizes used family labour only. Female labour is extensively utilised in farms. In addition, females owned most operations.

The number of production cycles per year determines the number of birds marketed per annum as well as the farm income. This can also be used as an indicator of market size within a given locality as well as the type of carcass desired by consumers. The present study showed that producers with more sheds had more production cycles per annum. However, the number of production cycles per annum is also related to the length of time broilers are kept on the farm before slaughter. All these factors have a direct relationship with the availability of market. During broiler farm budgeting, extension personnel use an average of 6 batches per annum, but the results of the present survey showed that small-scale farms reared an average of 4.4 batches per year. It appears that the producers with production cycles lower than 4.4 batches are limited either by the number of sheds or market availability. Furthermore, for small-scale broiler project budgets, an average of 4 to 5 batches per annum is probably more appropriate.

The number of production cycles per annum is also determined by the interval between broiler batches. The shorter the interval between broiler batches, higher will be the number of production cycles per annum, but a suitable interval is important to rest the sheds between batches to avoid any transmission of diseases. In Botswana, producers are advised to rest their sheds for at least two weeks between batches. The results of the present survey showed that most producers followed the extension advice as the interval was estimated at 1.8 weeks.

The preference of consumers in a marketing situation determines the quality of a product (Anon, 1996). Consumers in Botswana, especially in rural areas, prefer a reasonably big broiler carcass of about 1.6 kg. Factors that influence the size of broiler carcass are age and weight at slaughter. Because of the consumer preference, producers are forced to keep birds longer, which reduces profitability. There is no specific slaughter weight used in Botswana, but the Department of Animal Health and Production uses carcass weight of 1.3 kg and a slaughter age of 42 days for budgeting (Mosinyi, 1999). The average carcass weight found in this survey (1.46 kg) was higher and appears to reflect the real situation. It appears that the six-day increase in the number of days to slaughter observed in this survey (48 days) compared to that used for budgeting (42 days) is a market driven effect. It is suggested that 1.46 kg average carcass weight found in this study would be more appropriate as this reflects the current production levels. The 1.46 kg average carcass weight also relates well with the number of days broiler birds are kept as well as the preference of consumers in rural areas.

The present data showed that as the bird grows heavier, the feed conversion efficiency decreases; the birds have to eat more feed to meet their protein requirement. Energy intake, which is linked to protein intake, therefore is in excess of normal requirements and this excess is turned into carcass fat (Emmans, 1987; Swatland, 1995), resulting in reduced feed efficiency. This is a significant finding because small-scale producers in Botswana keep broilers longer to satisfy consumer preferences. The cost of keeping these birds is higher than any additional returns the producer makes from sales because of decreasing feed efficiency with increasing age. It is likely that the producers do not appreciate the economic impact of keeping the broilers longer and it is recommended the extension staff should advise small-scale broiler producers on this aspect.

The Department of Animal Health and Production uses 5-6 kg of feed per broiler per production cycle for budgeting. However, there is inconsistency between the value used by the government and the findings of the current study (4.6 kg). It is likely that the values used by the Department are conservative as there is no local data available on feeds, slaughter age and weights of broiler chickens.

The feed conversion ratio is the most important performance parameter that determines the profitability of broiler operations, but no FCR data is available under local conditions. The survey results showed the FCR to be 2.72 (kg feed/kg live weight). This FCR is considerably higher when compared to the Cobb breed standard of 1.60 kg feed/kg gain (Anon, 2001). The inferior FCR values in small-scale farms are probably, a result of poor quality feeds, management conditions, the length of the production cycle and feed wastage. This appears to be an accurate reflection of the situation in small-scale farms in Botswana and this FCR value can be used for budgeting especially when calculating cost price of products. More importantly, the inferior FCR is indicative of the considerable potential that exists for improvement under small-scale farm conditions.

Wood-based products have traditionally been the standard and preferred litter material in most broiler farms in Botswana. The majority of broiler producers (56%) however were found to use sawdust, which was largely due to the shortage and high cost of wood shavings. Even the available sawdust is often insufficient to completely cover the whole shed, as carpenters the sawdust suppliers in rural areas, are typically small-scale furniture manufacturers. Therefore, it was not uncommon to find that birds are placed on insufficient litter. Sawdust is a good litter material with high moisture absorbance, but it has a texture and density similar to that of feed, which leads to its consumption by chicks especially during the first two weeks. Malone & Chaloupka (1983) reported that consumption of sawdust at above 4% of total feed intake may reduce body weights and increase mortality. It is suggested that as the availability of these wood-based materials further decreases and prices increase, alternative cheaper and locally available material such as shredded paper, be utilised. Some authors have reported significant improvements in body weights, often with improved feed efficiency, in broilers reared on paper-based litters compared to broilers grown on wood shavings and/or sawdust (Malone *et al.*, 1982; Malone & Chaloupka, 1983).

Feeds are purchased from private agents who either source from the local feed milling company or import from South Africa and Zimbabwe. The quality and high cost of feeds continues to be a major problem. Most producers felt strongly that the Government should intervene and assist in providing cheaper feeds if small-scale broiler projects are to succeed.

For budgeting of broiler projects, the Department of Animal Health and Production uses 10% as the average mortality per batch. The present survey found that the average mortality was 9.15%, which is similar to the value used by the extension personnel. It should be noted that 20 producers, who have attended the Departmental training course, used a 10% mortality value, which may have influenced these results. Majority of the producers (42.4%) reported that Newcastle disease was a major concern to their farms. Broiler producers are advised to vaccinate against Newcastle disease at 21 days of age. Suppliers of day-old chicks also vaccinate the chicks as day-olds. Some broiler producers vaccinated against Infectious Bursal Disease as a precautionary measure.

Majority of the small-scale broiler producers sold their products at P15.00 per live bird or P8.50/kg dressed carcass. The calculation of production costs from data collected during the present survey showed that, to maintain profits, each live bird should be sold at P16.70. The lower selling price observed in this study may be related to local competition and the market price at which the producers have to sell their birds. It is also possible that lack of proper record keeping may have contributed to the selling at a price that is lower than the cost of production.

4.5 Conclusions

The aim of the present study was to obtain baseline information on specific aspects of production systems and productivity in small-scale broiler farms in Botswana. Small-scale producers had 4-5 production cycles per annum with an average interval between batches of two weeks. The average slaughter age was 48.3 days with a slaughter weight of 1 794g and a carcass weight of 1 418g. The average feed conversion ratio was estimated to be 2.72 (kg feed/kg live weight) and the average mortality was 9.15%. Overall, the performance indices of broilers under small-scale farm conditions are much poorer when compared to those recommended by the breeding companies, underlying the potential that exists to improve productivity and farm profits. There is indication from the survey that farmer-training courses were not beneficial as production parameters continued to be poor compared to the breeding company standards. The irregular feed supply contributed to poor production in some farms, highlighting the need to improve feed supply and its quality. Poor quality of day-old chicks may also have contributed to the low performance levels.

CHAPTER 5

GENERAL DISCUSSION

The objectives of the Agricultural Policy of 1991, proposed by the Government of Botswana, for the review of the performance of the agricultural sector, were to improve food security at the household and national levels, diversify agricultural production, increase agricultural output and productivity, increase employment opportunities, provide a secure and productive environment for agricultural producers, and conserve scarce resources for future generations (NDP 8, 1997). The most relevant objective to this present study was the diversification of the livestock base from beef to include other animal species. It is apparent that, to achieve this objective, the poultry industry should play a leading role, with specific focus within the industry on small-scale enterprises.

Small-scale poultry projects account for almost 80% of poultry operations in Botswana. Successive Governments have encouraged the growth of small poultry enterprises resulting in improvements in income levels, employment, import substitution as well as the nutritional status of the people. The local poultry industry has grown tremendously since the introduction of the Financial Assistance Policy (FAP), due both to an increase in the number of farms and a shift towards commercial intensive-type operations. Despite their importance, there is little published data available on production levels in small poultry farms.

In this study, small-scale poultry production systems in Botswana were surveyed. The primary objective was to obtain baseline information on specific aspects of production and productivity in layer and broiler farms. The results showed that the productivity, of both the layers and broilers, in small farms is below the breed standards. The small-scale poultry operations are characterised by a generally poor resource base, production inefficiencies, under-developed infrastructure and weak institutional links. The survey highlighted several areas of concern that constrain the realisation of the full potential of this sector. The specific constraints identified include inadequate livestock services, unavailability of easy credit for small-scale producers, poor farmer training, irregular feed supply, lack of quality control, irregular supply and poor quality of day-old chicks and point-of-lay pullets, poor on-farm records and lack of research on local poultry-related issues.

Efficient delivery of livestock services is a pre-requisite for successful livestock development. These services include the supply of feed and breeding stock, quality control, veterinary inputs, extension, research and marketing of products. In Botswana, the public livestock service delivery tends to concentrate efforts toward the beef industry. Delivery to the poultry sector is often inadequate and, more importantly, the input supply service (e.g. chicks, pullets, feeds, equipment) sector is largely controlled by private agents. It is widely acknowledged that the public services generally fail to reach small farmers. The shrinking of service coverage to small farms is a disturbing trend in developing countries and, consequently, small farms are also rapidly losing access to the remaining public service structures.

The availability of easy credit facilities and access to loans are essential for the sustainability of smallholder operations. The Government of Botswana assisted potential applicants with grants to establish their operations through the FAP. This policy has not fully achieved its aims because the target group, the small-scale producers in rural areas, do not have enough of a down payment to fully contribute towards their grants which has resulted in the approval of many projects that never got off the ground (Rebaagetse, 1998). Mayende (1992) reported that the dearth of income among most small peasant households undermines their capacity to acquire inputs despite the programme's favourable grant and down payment scheme. Those producers, who do manage to contribute towards their grants, had additional difficulty in accessing loans to expand their operations after the Government funding ceased. Commercial banks in Botswana view poultry farming as a risky business. This is a serious handicap that the small farmers, especially the poorer and emergent farmers face. The FAP has been made possible by the stable financial standing of Botswana, which is based on the mineral export boom. The recent fall in diamond revenue can be expected to reduce direct financial support to small-scale poultry farmers in the future. It is therefore necessary for the government to continue the FAP for small-scale producers, but in addition the Government through development banks, like National Development Bank, should introduce loans with low annual interest targeting mainly small-scale producers. It appears that policy development in Botswana should be aimed at cost recovery rather than outright grants.

Farmer training still remains the most significant means by which farmers learn about new technologies. A better trained class of farmers, who can effectively seek out and process new information and who could keep accurate financial records, is necessary to improve productivity levels and farm profits (Acheampong, 1996). Despite the training offered by the Department of Animal Health and Production to small-scale poultry producers, the present survey revealed that this course is either insufficient, or too short, for farmers to clearly understand the basics of good management. Proper training should therefore be provided initially for extension workers who can then in turn train the farmers (Safalaoh *et al*., 1998). Teacher training colleges should also teach poultry production courses so that this knowledge can trickle down to pupils in schools. The Government of Botswana could also make courses in poultry husbandry compulsory in schools as a way of disseminating information. The teaching of agriculture at all levels in schools, which is currently theoretical and focussed towards passing examinations, should be made more practical. In addition, Vocational Training Colleges should have compulsory subjects like agriculture so that the graduates could engage in productive self-provisioning agriculture. This strategy would also help reduce the high rate of unemployment experienced in Botswana, especially among the school leavers. Acheampong (1996) reported that the Government of Ghana made courses in poultry husbandry compulsory in schools as a way of disseminating better practices. This is a model that could be adopted in Botswana to further develop the poultry industry.

Feed supply and quality are major problems for small-scale poultry operators in Botswana. The feed is often expensive, with supply irregular and quality variable. As mentioned earlier, feeds are imported from South Africa and Zimbabwe or sourced from the local feed milling company. The local feed milling company is unable to meet the demand of the local market and, therefore low supply and high demand tend to push up prices. Most producers believe that imported feeds are of better quality than locally manufactured feeds. The non-availability of locally grown raw materials is a major concern because the country does not produce enough cereals to have a surplus for livestock feeds. As a result, the local feed company imports all ingredients necessary for its milling. The Government of Botswana currently subsidises cattle feeds because of the strong beef industry. But if the Government is fully committed to diversify the economy, price subsidies for poultry feeds should also be considered. It is important that the Botswana Poultry Association negotiates with the Government to consider this issue if the poultry industry is to develop through small-scale operators.

Almost all farmers reported that they were not satisfied with the quality of the feeds. This situation is similar to that reported in other African countries (Chiumia, 1996; cited by Safalaoh *et al*., 1998). Currently there is no legislation on poultry feed standards in Botswana, and feed manufacturers tend to exploit the situation. Chiumia (1996) observed that crude protein content of broiler starter feeds bought from several commercial feed compounders vary widely, ranging from 14 to 24%. While the labels on the feedbags consistently claim that that the feed contains 23% crude protein, the fact that it may contain levels as low as 14% is totally unacceptable. It should be noted that the National Research Council (1994) recommends a crude protein content of 23% for starter feeds. Poor quality feed represent a serious problem to the farmer and prevents birds from achieving maximum growth. Through proper government intervention, legislation on feed standards should be expedited to safeguard the poultry farmer by enforcing guaranteed feed analysis. The Botswana Bureau of Standards (BBS) should be responsible for enforcing these regulations and ensuring that the feeding standards are strictly followed. The Botswana Poultry Association should also take the lead in lobbying for this legislation. The poor feed efficiency values (2.72 kg feed/ kg live weight) found in this survey is partly a reflection of poor nutritional management. Nutritionally imbalanced feeds will not only lower growth rates and egg production, but also cause birds to increase their feed intake to satisfy their nutritive requirements. There may also be feed wastage on farms, which can further adversely affect the ratio of feed to gain or feed to egg production.

The shortage of day-old chicks and point-of-lay pullets is also a major constraint in Botswana. The local privately-owned hatchery is unable to meet the demand and in addition also imports hatching eggs since there are no parent stock projects in Botswana. For the poultry industry to thrive, the government and all stakeholders need to urgently address this situation. If the demand is not met, the hatchery should be encouraged to increase its imports, although this attracts additional transportation costs and compromises quality. Another potential solution would be to establish breeding stock farms and hatcheries to ensure an adequate supply of hatching eggs. Similar to the educational programme used by the Ghana Government (Acheampong, 1996), the Vocational Training Centres could start hatchery and breeding stock projects to supply the local market. Institutions like the Botswana College of Agriculture, possibly in collaboration with the Botswana Poultry Association, could also take advantage of this market as part of their curriculum. This is also advantageous to the college because graduates who are involved in these projects will be well vested in poultry production. If the situation with day-old chicks can be addressed, this will automatically solve the problem of lack of pullet supply in the country.

The growth of the poultry industry also require a strong research base on local issues. In the past, little or no research has centred on small-scale poultry enterprises. Research into the potential use of locally available and unconventional feedstuffs in poultry diets warrants priority attention. Simultaneously, studies on proper management practices and the economics of broiler and layer production should also be conducted. These efforts should be supported by context specific on-farm evaluations. It is important that farmers and extension staff should be involved in the identification of problems and the testing of new technology to ensure that appropriate solutions and technology are developed, demonstrated and provided.

It must be recognised that current intensive systems of raising poultry may not be financially viable long-term in Botswana, because of the strong dependence on external sources for all major inputs (chicks, pullets, feed etc). The Government, in association with organisations such as Botswana Poultry Association, should formulate policies to address these issues. Where necessary, externally funded investments in the poultry industry should be encouraged. The Botswana Confederation of Commerce, Industry and Manpower and Botswana Development Corporation could play a major role in this regard. Priority investment areas are feed manufacturing and the establishment of parent stock farms and hatcheries.

There is no proper egg and broiler marketing system in Botswana. Small-scale farmers have difficulty in gaining access to big retail outlets because they cannot offer a regular supply of eggs and broiler meat. This is disadvantageous to the small-scale farmers who cannot survive without a reliable market and may have to lower the prices to dispose of their products. In addition, due to a lack of refrigeration facilities, most small-scale producers sell their birds live. Generally, the prices offered for live birds are lower than those for dressed birds resulting in a loss. Also the local prices, which are determined by market forces of supply and demand, appear to be lower than the production costs. These are disturbing findings and imply that, unless a ready market is assured, the expected expansion of small farms will not be forthcoming. It is obvious that establishment of some type of co-operative marketing organisation is needed to facilitate the collection and sale of birds and eggs. Such an arrangement can benefit from economies of scale, where dealing in large quantities lowers unit costs. The proposed outlet should be manned by well-qualified personnel and have proper slaughter and cold storage facilities to ensure quality products. This type of marketing arrangement would ensure that farmers always have a ready market for their products. The Government, as it has done in the case of Botswana Meat Commission, should provide assistance in sourcing funds and inviting foreign investment. This strategy could provide employment for the locals and reduce the migration of labour to Gaborone in search of government employment (Akinboade & Lekwape, 1997).

The Government and Botswana Poultry Association must assess the advantages and disadvantages of contract farming as a way of expanding the poultry industry in Botswana. There are various reports from countries exporting poultry products on the success of contract farming, especially for small-scale farmers. In these countries, well-managed contract farming has proven effective in linking the small farm sector to technical advice, good quality feed and birds, and to guaranteed markets. If this approach is thoroughly investigated, the problems of the small farmers may be largely solved.

In some parts of the country, infrastructures are lying idle as a result of the outbreak of Contagious Bovine Pleuro Pneumonia in 1994. The Botswana Meat Commission plant in Maun for instance could be used for the benefit of the small-scale poultry producers in the area to provide facilities for slaughter, cooling and refrigeration. This could even be used as a distribution centre for all poultry products. Instead of the government privatising the plant, commercialisation may contribute to healthy economic growth and diversification to benefit the small-scale producer. It is the responsibility of the Botswana Poultry Association to lobby for the legislation to allow poultry producers to utilise these infrastructures.

5.1 Conclusions

The demand for livestock products, especially eggs and chicken meat, is income-elastic and rising continuously world-wide. Over the next decade, with rising income levels in Botswana, the demand is likely to grow faster. Domestic supply will satisfy the demand for eggs and meat only if the current trends in growth of poultry industry are sustained. However, the long-term viability of any animal industry is dependent on the extent to which its technical and economic requirements are met by existing government policies. In this context, the identification of farm-level constraints is essential when formulating policies and solutions to prevalent problems. Currently there is a serious lack of local information on these aspects and this was the focus of the present study. Baseline data have been generated on the performance levels in small poultry farms and the production systems have been characterised. This study, in addition to establishing the production standards, has raised several issues needing attention.

Findings of this survey revealed that several factors are crucial to the advancement of the poultry industry through the small-scale operations in Botswana: availability of easy credit, farmer training, efficient extension services, regular feed supply, good quality control, supply of good quality day-old chicks and point-of-lay pullets, a strong research base on local issues and an organised egg and broiler marketing system. The important question which should be considered is technical intervention in which of the above areas will result in the quickest and highest rate of return and improvement. This is a difficult question to answer. Perhaps, in the first instance, improved nutrition and livestock services (especially training and extension) are the areas that merit special consideration in the technological transformation of the poultry sector. The current livestock service system in Botswana is largely beef-oriented and the need for a flexible system to include other species is highlighted. The lack of quality control for and irregular supply of locally marketed feeds is another grey area and urgent government intervention is warranted to resolve this critical problem. The size of farm units may be increased and the industry can expand, only if there is a consistent local supply of quality feed to permit this.

In conclusion, it is obvious that any proposed technological changes must be accompanied by government policies aimed at improving infrastructures and support systems. Also a greater recognition of the wider context, including the role of women, local resource base and markets, is required if technical interventions are to succeed. Finally, the long-term sustainable development of small farms will depend *inter alia* on the interplay between the political, cultural and socio-economic milieu.

PART B

EVALUATION OF A NATURAL ZEOLITE IN BROILER DIETS

CHAPTER 6

GENERAL INTRODUCTION

Zeolites are hydrated aluminosilicate; minerals of volcanic origin that possess an infinite, three-dimensional structure. These structures give rise to unique adsorptive, catalytic and ion exchange properties. Zeolites have been evaluated as a feed additive to improve feed efficiency and health in poultry since 1970's, but conflicting results have been reported with regard their efficacy (Evans & Farrell, 1993). The variable results probably reflect the different types and sources of zeolites evaluated, and variability in product quality (Willis *et al*., 1982). Some reports suggest that zeolites can decrease the odour and moisture of chicken manure. Zeolites have been shown to control environmental pollution of nitrogen and phosphorus in intensive animal operations (Nguyen, 1997) and to reduce the adverse effects of mycotoxins (Yannakopoulos *et al*., 1998).

Zeolite use has been common in Russia and Japan for a number of years and is gaining popularity in other parts of the world (Lon-Wo & Cardenas, 1995). This technology, however, is not used widely in New Zealand livestock industry although some zeolite types are locally available. Of the forty types of naturally occurring zeolites, two are mined in New Zealand: Mordenite and Clinoptilolite. Mordenite is mined in the southern part of Whangarei and clinoptilolite in the central North Island.

6.1 Objectives of the study

The aim of the present study was to evaluate the usefulness of Mordenite on performance and litter quality when incorporated in broiler diets. The dose-response of Mordenite (0, 2.5, 5.0, and 7.5%) on the performance of broilers fed maize-soyabean based diets was examined in a five-week feeding trial.

6.2 Outline of Part B of the Thesis

This introductory chapter provides brief background information on zeolite use in poultry production. A review of literature is presented in Chapter 7, followed by the methodology and results from the experiment, which are discussed in Chapter 8.

CHAPTER 7

REVIEW OF LITERATURE

7.1 Introduction

Zeolites are hydrated aluminosilicate; minerals of volcanic origin that possess an infinite, three-dimensional structure. These structures give rise to unique adsorption, catalytic and ion exchange properties. They have the ability to lose and gain water reversibly and to exchange constituent cations without major changes of structure (Mumpton & Fishman, 1977). A large number of studies have been carried out investigating the potential of zeolites to improve the production efficiency of livestock including poultry, pigs and dairy cattle (Nakaue *et al.*, 1981; Evans & Farrell, 1990; Elliot & Edwards, Jr, 1991; Ramos & Hernandez, 1997; Maurice *et al.*, 1998). In several studies, emphasis was placed on the amelioration of negative effects of mycotoxins found in common feed ingredients (Ramos & Hernandez, 1997; Miazzo *et al.*, 2000; Oguz *et al.*, 2000). Some studies have also evaluated the effects of these mineral deposits on the environment of poultry houses and litter quality (Maurice *et al.*, 1998; Kithome *et al.*, 1999).

Of the forty types of naturally occurring zeolite, two are mined in New Zealand: Mordenite and Clinoptilolite. Mordenite is mined in the southern part of Whangarei, and the clinoptilolite in central North Island. Mordenite the harder of the two zeolites, does not break down in solution and absorbs 34% more ammonia-nitrogen (Nguyen, 1997).

Many claims have been made, in the popular literature, concerning the usefulness of zeolites in the diets for poultry. These minerals have been claimed to improve egg production (layers, broiler breeders), egg size (layers, broiler breeders) and feed efficiency (layers and broilers), enhance resistance to heat stress (layers and broilers), improve egg shell quality as measured by specific gravity (older layers), reduce incidence of cracked eggs (older layers), non collectable eggs (older layers), incidence of egg body checks (older layers), and mortality (layers and broilers), improve fertility (breeders), feather quality (layers and broilers), bone structure (layers) and utilisation of calcium (Ca) and other nutrients in the diet (layers), lead to heavier hatched chicks (broiler breeders), reduce malodour of manure and improve value of the manure (layers and broilers). However, a comprehensive review by Evans & Farrell (1993) showed that evidence for most of these claims is contradictory.

7.2 Zeolites

Zeolites are a group of more than 40 aluminosilicates, among which, the most important ones are clinoptilolite and mordenite (Mumpton & Fishman, 1977; Castro & Lo-Wo, 1991). Zeolites have properties which allow their application in the fields of industrial technology, agriculture, construction and health. They are aluminium and silicon compounds with well defined molecular geometry and have pores (full of water) connected in such a way that they form canals and cavities allowing the entry and loss of water and the exchange of cations contained in their structure (Waldroup *et al.*, 1984; Castro & Lo-Wo, 1991).

Synthetic and natural types of zeolites, which have markedly different composition, have been evaluated in livestock diets. The most commonly used synthetic zeolite is sodium zeolite which has the chemical composition $Na_{12}[(AlO_2)_{12}(SiO_{12})_{12}]\cdot 27H_2O$. The most commonly used natural zeolite is clinoptilolite and this has the chemical composition $CaNa_4K_4(AlO_2)_6(SiO_2)_{30}24H_2O$ (Elliot *et al.*, 1991). Natural zeolites are crystalline, hydrated aluminosilicates with absorption and ion exchange properties (Maurice *et al.*, 1998), while synthetic zeolite (sodium aluminium silicate) is a crystalline, hydrate aluminosilicate of alkali and alkaline earth cations, having an infinite 3-dimensional structure (Evans *et al.*, 1990). In comparison to natural zeolites, the structure of synthetic zeolites breaks down in the acidic gastric environment, releasing aluminium and silicon hydroxide into the system (Moshtaghian *et al.*, 1991).

7.3 Effects of zeolites in poultry production

Published data on the effects of zeolites in poultry production is contradictory. There are numerous studies carried out on the effects of zeolites in reducing mycotoxin effects in feed ingredients on poultry performance, with most of the studies focusing on broilers. There is clear evidence in the literature that some of the claims made concerning the usefulness of zeolites in poultry are unfounded. An excellent review on the use of zeolites, covering the literature published prior to 1989, is already available (Evans & Farrell, 1993). The purpose of this chapter will not be to revisit material that has been extensively reviewed by these authors. Rather, the intention is to provide a general overview focussing more emphasis on materials published since 1989.

7.3.1 Protective effects of zeolites on chickens

Aflatoxins are natural contaminants of feedstuffs and are toxic metabolites produced by some *aspergillus* species. The signs of aflatoxicosis in poultry include anaemia, inhibition of immune function, hepatotoxicosis, mutagenesis, teratogenesis and carcinogenesis (Keçeci *et al.*, 1998; Oğuz *et al.*, 2000). According to Keçeci *et al.* (1998), decreased total protein and albumen are consistent indicators of aflatoxin hepatoxicity in chickens and turkeys as determined from serum biochemical and haematological changes. Numerous studies have been carried out in the last decade using zeolites to determine the protective effects of mycotoxins on the health and performance of broiler chickens and the results from these studies are summarised in Table 7.1.

Table 7.1 Summary of published data (1989-2000) – Effects of zeolites on the performance and serum parameters of poultry fed diets contaminated with aflatoxins.

Parameter	No. of[1] experiments	Positive effects	No effects	Negative effects
Serum uric acid	3	2	1	-
Thrombocyte counts	1	-	1	-
Weight gain	3	3	-	-
Feed conversion ratio	2	2	-	-

[1] Total of nine experiments (Scheideler, 1989 & 1993; Lon-Wo *et al.*, 1993; Harvey *et al.*, 1993; Kubena *et al.*, 1993; Keçeci *et al.*, 1998; Curtui, 2000; Oğuz *et al.*, 2000; Miazzo *et al.*, 2000).

Scheideler (1989, 1993) observed that the inclusion of hydrated sodium calcium aluminosilicate (HSCAS) alleviated the depression of growth elicited by the presence of 2.5 mg aflatoxin B_1 per kg feed, caused a 50% improvement in growth and suppressed the increase of liver lipids caused by mycotoxins. There was also an increase in serum phosphorus, which is normally depressed in aflatoxicosis. Kubena *et al.* (1993) also observed that HSCAS compounds provided significant protection against changes in total protein, albumen and cholesterol concentrations during aflatoxin infections. In contrast, Harvey *et al.* (1993) and Keçeci *et al.* (1998) similarly observed no amelioration of the decreased serum profiles of chicks inoculated with aflatoxin plus synthetic zeolite. Keçeci *et al.* (1998) did not observe any improvement in the thrombocyte counts of chicks inoculated with aflatoxin plus synthetic zeolite. These workers found that that polyvinylpolypyrolidone and bentonite are more effective than synthetic zeolites in ameliorating the effects of aflatoxicosis.

Miazzo *et al.* (2000) observed no significant difference between the weight gains of chicks fed control diets and those fed diets containing aflatoxin and zeolite. The results indicated that zeolite provided total protection against the negative growth effects generally caused by aflatoxins. There were, however, no significant differences in feed efficiency between the two groups. While many researchers reported total protection and positive effects in serum profiles when zeolites are used, Oğuz *et al.* (2000)

observed that the decrease in inorganic phosphorus in chicks as elicited by inoculation with aflatoxin were only partially improved by the dietary addition of two doses (1.5 and 2.5%) of clinoptilolite. However, the study also reported a significant ($P < 0.05$) reduction in serum uric acid in chicks given aflatoxin, which was improved by the addition of clinoptilolite, a result in agreement with Keçeci *et al.* (1998). The recent published data, therefore, suggests a consistency of the effects of zeolites in the amelioration of aflatoxicosis in broiler chickens.

The water absorption ability of the intact structure of natural and synthetic zeolites appear to have a practical role in delaying the onset of mould growth, when blended with grain and poultry feeds having 20% moisture (Evans & Farrell, 1993). This is a useful attribute of zeolites and other aluminium silicates that can be exploited in the absence of alternative methods of reducing moisture content in grains intended for storage. It is reported that this mechanism may also help to reduce the excreta moisture content in birds fed diets containing natural zeolites (Waldroup *et al.*, 1983).

7.3.2 Effects of zeolites in broiler performance

Studies have shown clear differences between the effects of natural and synthetic zeolites on the performance of broilers. These differences may be related to the composition of these compounds, as discussed in section 6.1.

7.3.2.1 Use of synthetic zeolite in diets for broilers

Early research showed conflicting evidence for the influence of synthetic zeolites (Evans & Farrell, 1993) with some studies showing positive results while others reporting negative or no effects. A review of recent literature indicates a similar pattern (Table 7.2) with many effects of synthetic zeolite on broiler performance contradictory.

Table 7.2 Summary of published data (1988-1995) – the effects of synthetic zeolites on the performance of broiler chickens.

Parameter	Number of[1] experiments	Positive effects	No effect	Negative effects
Growth rate	7	2	2	3
Body weight	6	3	1	2
Feed consumption	4	-	2	2
Feed efficiency	6	2	2	2
Mortality	1	1	-	-
Manure moisture	3	3	-	-
Carcass yield	2	-	2	-
Carcass fat	1	1	-	-
Leg problems	7	2	3	2

[1] A total of eight experiments are cited (Ballard & Edwards, 1988; Edwards, 1988; Watkins *et al*., 1989; Leach *et al*., 1990; Lon-Wo & Gonzalez, 1990; Castro & Lon-Wo, 1991; Yalcin *et al*., 1995; Lon-Wo & Cardens, 1995).

Yalcin *et al*. (1995) observed that the inclusion of synthetic zeolite resulted in higher ($P < 0.01$) body weight, carcass weight and carcass part weights in broiler lines selected for high incidence of tibial dyschondroplasia. There were, however, no differences in carcass yield. The inclusion of synthetic zeolite increased the percentage of tibia ash ($P < 0.05$), but had no effect on the incidence or severity of tibial dyschondroplasia. Lon-Wo & Cardenas (1995), evaluating six sources of zeolites, found that the inclusion of zeolites in maize-based diets improved the feed efficiency of broilers, irrespective of the source of the deposit. All zeolite deposits improved efficiency, but some showed better responses than others. It was also noted that some deposits showed relatively better improvements when used in wheat-based diets. The better bird performance observed in some studies has been attributed to a delay in the rate of passage through the gastrointestinal tract (Castro & Lon-Wo, 1991).

The effects of zeolites in broiler diets appear to be better when suboptimal diets are used. Ballard & Edwards (1988) reported that supplementary synthetic zeolite added to low-calcium broiler diets, improved tibia bone ash and reduced the incidence and severity of tibial dyschondroplasia. This is in agreement with the findings of Leach *et al.* (1990) who fed diets that were deficient in calcium (0.31, 0.39 and 0.47%) and concluded that there was little benefit from adding synthetic zeolite to diets adequate in calcium. Watkins *et al.* (1989) reported that an inclusion of 0.75% synthetic zeolite exacerbated the adverse effects of calcium toxicity in broiler chicks by further decreasing weight gain, feed intake, and tibia bone ash in chicks fed excess dietary calcium. Leach *et al.* (1990), on the other hand, reported that the inclusion of 0.75 and 1.5% synthetic zeolite improved growth rate and tibia bone ash and decreased the incidence of rickets when supplemented into diets that were deficient in calcium. In the study of Edwards (1988), supplementation of synthetic zeolite to low-phosphorus broiler diets significantly reduced weight gain, tibia bone ash, and the retention of phytate phosphorus.

In maize-based broiler diets with low protein and energy levels, it has been suggested that zeolites are beneficial and improve the efficiency of utilisation of nutrients (Lon-Wo & Gonzalez, 1990). Evans and Farrell (1993), however, maintained that there was no justifiable evidence to support the use of zeolites in poultry diets.

7.3.2.2 Use of natural zeolites for broilers

The review by Evans & Farrell (1993) concluded that the addition of natural zeolite (clinoptilolite) in broiler diets had limited economic benefit or application for improving bird performance. A summary of recent published literature is given in Table 7.3, which, generally, agrees with the conclusions of Evans & Farrell (1993).

Table 7.3 Summary of published data (1983-1993) – the effects of natural zeolites on the performance of broiler chickens.

Parameter	Number of[1] experiments	Improved effects	No effect	Negative effects
Growth rate	2	1	1	-
Body weight	4	2	2	-
Feed consumption	3	-	1	2
Feed efficiency	7	5	2	-
Mortality	2	2	-	-
Manure moisture	2	2	-	-
Carcass yield	-	-	-	-
Carcass fat	-	-	-	-
Leg problems	1	-	1	-

[1] A total of seven experiments are cited (Willis *et al.*, 1982; Waldroup *et al.*, 1983; Lon-Wo *et al.*, 1987; Lon-Wo & Gonzalez, 1990; Elliot & Edwards, 1991; Castro & Lon-Wo, 1991; Evans & Farrell, 1993).

Interestingly, however, consistent effects of natural zeolite on feed efficiency in broilers have been reported. Lon-Wo *et al.* (1987) observed better ($P < 0.05$) feed efficiency and lower mortality after the inclusion of zeolite in broiler diets. These authors recommended the use of 5% zeolite in broiler diets and stated that it could be used throughout the fattening period. Lon-Wo & Gonzalez (1990) studied the effects of zeolites on broiler birds from 7 to 21 days on diets with low or adequate protein. The only significant effect was on the feed efficiency, which was improved in the low protein diet with zeolite. The inclusion of zeolite, regardless of protein level of the diet, significantly ($P < 0.01$) decreased feed consumption, with a favourable effect of feed efficiency. Weight gains did not differ between the dietary treatments.

Elliot & Edwards (1991) also observed significant improvements in feed efficiency when natural zeolite was included in broiler diets, with no effects on weight gain or the severity of tibial dyschondroplasia. Castro & Lon-Wo (1991) observed some improvements in weight gain and feed efficiency in broilers fed diets containing natural zeolites. Waldroup *et al.* (1983) observed no beneficial on body weights or feed efficiency when broiler diets were supplemented with 1% zeolite.

The review of Evans & Farrell (1993) showed a tendency for improvement in broiler growth rate with the inclusion of zeolites, but they recommended that the commercial use of natural zeolites in poultry diets should not be made routine. Based on the conflicting published data, they concluded that there was little evidence to suggest that natural zeolites are anything more than good dietary fillers or diluents. Some reports, however, indicate that the use of zeolites lowers excreta moisture levels and unpleasant odours, thereby improving the physical and hygienic conditions of the litter (Castro & Lon-Wo, 1991).

7.3.2.3 Use of synthetic zeolites in diets for laying hens

Several studies have been carried out to evaluate the effects of synthetic zeolite on the performance of layers, but again there are inconsistencies in the results reported by different authors (Evans *et al.*, 1990; Evans & Farrell, 1993). Results from 15 published studies are summarised in Table 7.4.

The table below shows that manure moisture content is the only parameter that was consistently improved by zeolite inclusion. Evans *et al.* (1990) observed no effects of synthetic zeolite in alleviating the effects of heat stress in layers in terms of egg production, egg weight, egg mass, feed consumption, feed efficiency, shell weight and egg specific gravity. Evans & Farrell (1993) observed significant negative effects of synthetic zeolites on layer birds including reduced growth rate, body weight and egg production. Elliot & Edwards (1991) observed significantly reduced weight gains and tibia bone ash in layers fed diets containing synthetic zeolites. In this study, synthetic zeolites had no effect on egg specific gravity, but significantly reduced egg weight, egg production, plasma dialysable phosphorus, and the retention of phosphorus and phytate phosphorus. However, greatest effects of synthetic zeolites were on egg weight and egg production.

The effects of zeolites in layer diets again appear to be better when low-calcium diets are used. Roland & Dorr (1989) observed some improvement in eggshell quality when synthetic zeolite was used in layer hen diets with the improvements more pronounced in birds fed suboptimal dietary calcium levels.

Table 7.4 Summary of published data (1989-2000) – the effects of synthetic zeolites on the performance of laying hens.

Parameter	Number of[1] experiments	Positive effects	No effects	Negative effects
Body weight	2	1	1	-
Egg production	5		2	3
Egg weight	6	-	5	1
Egg quality	1	-	1	-
Feed consumption	4	-	2	2
Feed efficiency	2	1	1	-
Manure moisture	6	6	-	-
Shell quality	2	1	1	-
Egg specific gravity	5	2	2	1
Heat stress	1	-	1	-

[1] A total of 7 experiments reviewed (Roland & Dorr, 1989; Evans, 1989; Evans *et al.*, 1990; Elliot & Edwards, 1991; Evans & Farrell, 1991; Frost & Roland, 1992; Evans & Farrell, 1993).

7.3.2.4 Use of natural zeolites in layer diets

There is no consistency in the published data on the influence of natural zeolites on performance of laying hens (Nakaue & Koelliker, 1981; Olver, 1983; Evans and Farrell, 1993). The data summarised in table 7.5 again show that feed efficiency is the only parameter showing any consistency.

Table 7.5 Summary of published data (1989-1998) – the effects of natural zeolites on the health and performance of laying hens.

Parameter	Number of[1] experiments	Positive effects	No effects	Negative effects
Growth rate	3	-	2	1
Body weight	4	-	3	1
Egg production	4	2	2	-
Egg weight	5	1	4	-
Feed consumption	4	1	3	-
Feed efficiency	6	5	1	-
Manure moisture	2	2	-	-
Shell quality	4	2	2	-
Mortality	2	2	-	-

[1]A total of 8 experiments cited (Nakaue & Koelliker, 1981; Olver, 1983,1989; Elliot & Edwards, 1991; Castro & Lon-Wo, 1991; Evans & Farrell, 1993; Yannakopoulos *et al.*, 1998, Ozturk *et al.*, 1998).

Nakaue & Koelliker (1981) in studies with White Leghorn hens, observed no effect of clinoptilolite (natural zeolite) on egg production, feed intake and feed efficiency. In contrast, Olver (1983) observed negative effects ($P < 0.05$) from feeding clinoptilolite to Hy-Line laying hens with regard to age at first egg, feed intake per hen, moisture content of the droppings and intestinal bacterial colony and increased number of eggs laid per hen and feed efficiency. These results suggest that strain differences may be responsible, at least in part, for the variability in responses to natural zeolite inclusion. The studies of Olver (1989) also showed that some layer strains responded better in terms of egg production than others to zeolite supplementation. For example, he found that Tetra SL hens were responsive than the SH Brown or the Hybrid Gold hens.

Olver (1989) reported that zeolite inclusion had no effect on body weight and age at first egg of pullets. This contrasted with earlier work, which found that inclusion of natural zeolite had no effect on body weight but significantly ($P < 0.05$) lowered the age at first egg (Olver, 1983).

Elliot & Edwards (1991) compared the effects of synthetic and natural zeolites (at a 1% inclusion level) on the performance of layers and broilers. It was observed that natural zeolites had no effect on egg weight, egg production, plasma calcium, plasma phosphorus, or on the retention of calcium, phosphorus and phytate phosphorus. Synthetic zeolite supplementation, on the other hand, significantly increased egg specific gravity, while egg weight and egg production were unaffected. Phytate phosphorus retention and plasma dialysable phosphorus were significantly reduced by synthetic zeolite inclusion in the diets. Castro & Lon-Wo (1991) observed a higher feed efficiency and a lower feed consumption when hens were fed diets containing 10% natural zeolites, with egg weight and the shell quality unaltered by treatments. Evans & Farrell (1993), however, state that the ability of natural zeolites to improve feed efficiency in laying hens occurs at the expense of body weight rather than as a true improvement in feed or nutrient utilisation.

Yannakopoulos *et al.* (1998) evaluated the effects of natural zeolite on the yolk:albumen ratio in hen eggs and observed an increase in both egg weight and albumen weight, while egg yolk was unaffected. These results contrast with those reported by other workers (Castro & Lon-Wo, 1991; Evans & Farrell, 1993). Ozturk *et al.* (1998) observed no significant dietary effects in terms of body weight, feed intake, feed efficiency, number of eggs laid per hen, shell thickness, mortality or other egg quality parameters. However, there was a significant decrease ($P < 0.05$) in excreta moisture content with natural zeolite supplementation.

In conclusion, this review suggests that many of the commercial claims made concerning the use of natural zeolites in poultry diets cannot be fully substantiated.

7.3.3 Mode of action of zeolites

There are major differences between the mode of action of synthetic and natural zeolites, and these are related to the stability of the zeolite structure within the gastrointestinal tract and the presence of detrimental contaminants (Evans *et al.*, 1990). The structure of synthetic zeolites breaks down under the influence of the acidic gastric environment, releasing aluminium and silicon hydroxide into the system (Elliot & Edwards 1991; Moshtagian *et al.*, 1991). The synthetic zeolites provide high levels of silicon hydroxide following acid hydrolysis compared to natural zeolites due to their unique structure consisting solely of monomeric silicate units.

Some studies indicate that birds retain aluminium released into the gastrointestinal tract and this retention increases with increasing dietary levels of synthetic zeolite included in the feed (Evans & Farrell, 1990). The retention of aluminium has implications not only in terms of aluminium toxicity and subsequent adverse effects on bird performance (Hussein *et al.*, 1989; Elliot & Edwards, 1991) but also for humans further up the food chain (Evans & Farrell, 1990). Studies have also shown that some of the aluminium combines with dietary phosphorus and influence phosphorus utilisation (Edwards, 1988; Elliot & Edwards 1991b; Moshtaghian *et al.*, 1991). The extent of this influence on bird performance is, however, dependent on the level of phosphorus in the diet (Watkins & Southern, 1992). There are reports that at high dietary levels of phosphorus (> 0.5%), synthetic zeolites do not modify the response to phosphorus which has led some researchers to conclude that the effect of synthetic zeolite in improving egg shell quality may be independent of dietary phosphorus level (Moshtaghian *et al.*, 1991). In contrast, birds fed low-phosphorus diets (< 0.3%) with 1% synthetic zeolite experienced a more rapid and greater decline in egg production than those fed 0.3% total phosphorus without synthetic zeolite supplementation (Roland, 1990).

Inclusion of synthetic zeolites in poultry diets at levels above 1% has been reported to be detrimental on both layer and broiler performance. This is shown by reductions in egg production, egg weight, feed consumption and body weight and growth rate (Evans *et al.*, 1990; Lon-Wo and Gonzalez, 1990; Evans & Farrell, 1993). It has been proposed that the presence of high levels of residual hydroxyl ions in synthetic zeolite is one factor contributing to the lowered performance of layers and broilers. The effect is mediated through an increase in the pH of the anterior segments of the gastrointestinal tract, particularly at dietary inclusion levels above 1%.

In comparison to synthetic zeolites, the effects of the acidic gastric environment on the structure of natural zeolites are unlikely to be as severe. Evans & Farrell (1993) reported that this is due to the greater ratio of silicon to aluminium atoms in the structure of natural zeolites, which provides a more stable structure. When aluminium contents of lung, brain, skeletal muscle, liver and kidney tissue were measured, there were no differences between birds fed diets containing natural zeolites or the control diet (Evans *et al.*, 1990; Evans & Farrell, 1993). These findings suggested that aluminium remains within the zeolite structure in natural zeolites.

There are conflicting reports on the effects of natural zeolites on poultry performance (Evans & Farrell, 1993). It is thought that the observed differences in responses may be due to the differences in composition and structure of various zeolites. It is therefore, important to evaluate individual types of natural zeolite. The effects of natural zeolites also appear to be influenced by particle size. Evans *et al.* (1990) showed a significant ($P < 0.05$) relationship between the particle size of zeolites and the retention of potassium, magnesium, manganese and zinc in bird tissues. This observation probably reflects the active cation exchange activity of zeolites. It was concluded that the use of natural zeolites of low particle size affects mineral retention due to cation exchange with the zeolites structure, particularly in diets, which may be marginally deficient in minerals.

The mechanism by which diets containing zeolites influence egg production in hens is unknown. Some reports suggest that zeolites may absorb ammonia (NH_4^+) by ion exchange (Mumpton & Fishman, 1977). It has therefore, been postulated that zeolites assist in the removal of stress-forming ammonia from the gut, and by doing so increase egg production (Olver, 1989). There have been some reports of improved egg shell thickness when hens are fed diets containing zeolite (Olver, 1989; Elliot & Edwards, 1991). This increase in shell thickness and egg specific gravity may be due to the fact that when an ion is adsorbed into the structure of zeolite another ion important for shell structure such as calcium, is desorbed. This ion exchange property of zeolite could lead to more calcium becoming available and may account for the thicker shells observed in zeolite fed hens (Mumpton & Fishman, 1977; Olver, 1989; Roland, 1990).

Another mode of action identified for zeolites is the effect on the rate of passage of digesta. It was postulated that natural zeolites slow the rate of passage through the gastrointestinal tract allowing more time for digestion and absorption, and improvements in feed efficiency (Lon-Wo *et al*., 1987; Evans *et al*., 1990). The inclusion of zeolites has been shown to increase the mean retention time of digesta in broilers and layers (Evans *et al*., 1990; Evans & Farrell, 1993). This mode of action is a general attribute of aluminium silicates (Castro & Lon-Wo, 1991). Dietary inclusion of zeolites also affects other physiological factors within the animal including digestion, the nature of the metabolic processes and the morphological and physico-chemical indexes of certain tissues and organs (Evans & Farrell, 1993).

CHAPTER 8

MATERIALS AND METHODS

8.1 Introduction

The usefulness of natural zeolites in poultry diets has been evaluated in work over years, and is reviewed in Chapter 7. Clinoptilolite was the natural zeolite evaluated in all reported studies. To my knowledge, Mordenite, the other commonly occurring natural zeolite, has never been tested. In the present study, the dose-response of Mordenite on broiler performance was examined. The experiment described herein was conducted at the Poultry Research Unit, Turitea Campus, Massey University, Palmerston North.

8.2 Mordenite

The Mordenite used in the study was supplied by Zeotech Limited, Auckland. According to the supplier, Mordenite was specified to contain a cation exchange capacity, 110.5 meq/100g; ammonia exchange capacity, 140-156 meq/100g; ammonia gas absorption, 76-160 meq/100g and water content, 11.2 g/100g. Mineral composition (g/100 g) was as follows: phosphorus 0.09; aluminium 10.94; potassium 0.94; calcium 5.02; sodium 1.86 and magnesium 0.50. The product contained the following mineral types: Mordenite, > 60%; alpha quartz, 9%; calcite, 3-5% and mica clays, < 10%. The particle size was agricultural lime grade.

8.3 Animal Housing

8.3.1 Brooder room

An environmentally controlled brooder room (≈28 ^{0}C) was used to rear the chickens to 14 days of age. The room temperature was regulated and maintained by using radiated heaters and a heat sensor-controlled ventilation fan. The brooding unit consisted of four, three-tier blocks of cages, with four cages per tier (two on each side). Each pen in the brooding unit measured 76 cm x 42 cm (532 cm^2/bird). Each cage had its own feeding trough, but shared a drinking trough with the adjacent pen. The cages were electrically heated and the pen temperature was maintained at 36 ^{0}C during day 1 to 4, 34 ^{0}C from day 5 to 10, and 30 ^{0}C to day 14. On day 14, all birds were transferred to a grower shed. A lighting cycle of 23-hour light and 1 hour darkness was provided.

8.3.2 Grower Shed

The grower shed consisted of colony cages (60 cm x 60 cm; 600 cm^2/bird), each of which had an individual cup drinker. Three cages shared a long feeding trough, and diets fed to the different cages were separated by metal partitions. The shed temperature was gradually reduced by about 0.5 ^{0}C per day from 27 ^{0}C at day 14 to 21 ^{0}C on day 35. The lighting cycle of 23-hour light and 1 hour darkness was maintained. The birds were housed in the grower shed until the termination of the trial on day 35.

8.4 Preparation of Experimental Diets

8.4.1 Ingredients used

A maize-soyabean meal diet served as the control diet and three experimental diets were formulated to contain graded levels (2.5, 5.0 and 7.5%) of Mordenite (Table 8.1). Each diet was formulated using table compositional values for the ingredients (NRC, 1994) to provide similar levels of apparent metabolisable energy, lysine and methionine plus cysteine. Maize was ground using a hammer mill with 4-mm screen size prior to feed mixing. The calculated dietary nutrient concentrations met or exceeded the recommended requirements for broiler starters (NRC, 1994). The composition of the vitamin and mineral premix are shown in Table 8.2.

Table 8.1 Percentage composition and calculated analysis of diets.

Ingredient	Control	2.5% Mordenite	5.0% Mordenite	7.5% Mordenite
Maize	62.26	57.69	52.52	47.64
Soyabean meal	32.50	33.50	34.50	35.50
Mordenite	0.00	2.50	5.00	7.50
Vegetable oil	1.30	2.40	4.10	5.30
Dicalcium phosphate	1.55	1.55	1.55	1.55
Limestone	1.22	1.22	1.22	1.22
Lysine.HCl	0.20	0.18	0.16	0.14
DL-methionine	0.36	0.36	0.36	0.36
Threonine	0.06	0.05	0.04	0.03
Salt	0.25	0.25	0.25	0.25
Trace mineral premix[1]	0.25	0.25	0.25	0.25
Vitamin premix[1]	0.05	0.05	0.05	0.05
Calculated analysis				
AME (kcal/kg)	2910	2910	2915	2905
Crude protein (%)	21.1	21.2	21.3	21.4
Lysine (%)	1.15	1.15	1.15	1.15
Methionine + cystine (%)	0.90	0.90	0.90	0.90
Calcium (%)	0.90	0.90	0.90	0.90
Available phosphorus (%)	0.40	0.40	0.40	0.40

[1] Supplied by Tegel Foods, Auckland. See Table 8.2 for composition.

Table 8.2 Composition of vitamin and trace mineral premixes used in the experiment.

Vitamin (per kg finished feed)		Mineral (per kg finished feed)	
Vitamin A, I.U	11.1	Mn, mg	125.0
Vitamin D, I.U	2.4	Zn, mg	60.0
Vitamin E, mg	60.0	Cu, mg	5.0
Vitamin K, mg	4.0	Co, mg	0.3
B_1 Thiamine, mg	3.0	Fe, mg	25.0
B_2 Riboflavin, mg	12.0	I, mg	1.0
B_3 Nicotinic, mg	35.0	Mo, mg	0.5
B_5 Pantothenic, mg	12.8	Se, mg	0.2
B_6 Pyridoxine, mg	10.0	Choline, mg	637.5
B_{12}, mg	0.017		
Folic, mg	5.2		
Biotin, mg	0.2		
Antioxidant, mg	100.0		

8.4.2 Feed Mixing

All macro-ingredients, weighing less than 10 kg in the total mix, and micro-ingredients were first weighed out using a Mettler AE 163 balance and mixed thoroughly in a Hobart mixer. They were transferred to a horizontal mixer, where further mixing with the rest of the macro-ingredients was carried out. All the micro-ingredients were weighed on the Mettler AE 163 balance. After mixing, the diets were cold-pelleted (~65-70 ^{0}C) through a 3-mm die.

8.5 Animals

A total of 240 day-old male broiler chickens (Ross strain) were obtained from the Tegel Hatchery, Levin, New Zealand. The chicks were hatched in the morning and delivered to the research unit by noon the same day. On arrival, all birds were weighed and placed into narrow weight classes. Birds at the low or high end of the bodyweight distribution were discarded. Six chicks were then assigned to each of 40 pens such that all pens had similar weights. The pens were then randomly assigned between the four treatment groups (0, 2.5, 5.0 and 7.5% Mordenite), thus giving 10 replicates per treatment. All birds were given *ad libitum* access to feed and water.

8.6 Experimental Procedures

8.6.1 Measurements

Birds were observed twice daily and any mortality was recorded. Body weights and feed intake were recorded at weekly intervals. On Days 14 and 18, excreta were scored for manure quality on a scale of 1 to 5 (1 = normally formed excreta and 5 = representing pasty and very sticky excreta).

8.6.2 Collection of excreta samples

Excreta samples were obtained on Day 20 for the determination of excreta moisture, phosphorus and nitrogen. On Day 20, a metal tray was placed under four randomly selected cages per treatment. After 4 hours, the trays were removed and excreta samples obtained. The excreta samples were placed in labelled airtight plastic bags, weighed and frozen at –20 ^{0}C. Subsequently, the samples were freeze-dried and dry matter percentage was determined. The dried samples were ground to pass through 1-mm sieve for subsequent laboratory analysis.

8.6.3 Calculations

Feed conversion ratio (FCR) was calculated as follows:

$$\text{FCR (g/g)} = \frac{\text{Weight gain (g)}}{\text{Feed intake (g)}}$$

8.6.4 Chemical Analysis

Diet samples were submitted to the Food and Biological Chemistry laboratory, HortResearch, Ruakura, Hamilton for analysis of mycotoxin levels. Total phosphorus and nitrogen were determined following Kjeldahl digestion by colorimetric autoanalysis (Twine & Williams, 1971; Technicon, 1973).

8.7 Statistical analysis

The data was subjected to analysis of variance by the General Linear Models procedure of the Statistical Analysis Systems Institute (SAS, 1997) using pen as the experimental unit. Differences were considered significant at $P<0.05$ and significant differences between means were separated using the Least Significance Difference (Snedecor & Cochran, 1980). Linear and quadratic effects were tested with orthogonal polynomials (SAS, 1997).

8.8 Results

The effects of varying levels of Mordenite on the performance, moisture, nitrogen and phosphorus contents of excreta and excreta quality are shown in Table 8.3.

8.8.1 Body weight gain

Increasing dietary levels of Mordenite significantly affected weight gain in a linear ($P = 0.02$) and quadratic ($P = 0.02$) fashion (Table 8.3). Inclusion of 2.5% Mordenite improved weight gain of broilers by 4.1% when compared to the control diet with no Mordenite (2 173 versus 2 088 g/bird), but the differences were not statistically significant ($P > 0.05$). Weight gains of birds fed diets containing 5.0% Mordenite were similar ($P > 0.05$) to those fed the control diet. There was, however, a significant ($P \leq 0.05$) depression in weight gain of birds fed the 7.5% Mordenite diet compared to those fed the diet with 2.5% Mordenite.

8.8.2 Feed intake

Increasing levels of Mordenite had a linear ($P = 0.03$) effect on feed intake (Table 8.3). Inclusion of Mordenite at 2.5 and 5.0% had no effect ($P > 0.05$) on feed intake compared to the controls. But, the feed intake of birds fed diets containing 7.5% Mordenite was significantly lower (P < 0.05) than those on the 2.5% Mordenite diets.

Table 8.3 Influence of graded levels of Mordenite on the performance and excreta quality of broiler chickens reared from 1-35 days of age.

	Control diet	2.5% Mordenite	5.0% Mordenite	7.5% Mordenite	Pooled SEM
Initial weight (g)	45	46	45	45	-
Weight gain (g)	2088^{ab}	2173^{a}	2084^{ab}	1992^{b}	33.4
Feed intake (g)	3147^{ab}	3197^{a}	3103^{ab}	3035^{b}	41.2
FCR (g/g)	1.510^{a}	1.474^{a}	1.495^{a}	1.522^{b}	0.012
Excreta moisture (%)	77.9	76.1	74.2	74.4	1.13
Excreta nitrogen (%DM)	5.518^{a}	5.070^{a}	4.404^{b}	3.940^{c}	0.188
Excreta phosphorus (%DM)	1.683^{a}	1.464^{b}	1.407^{b}	1.207^{c}	0.027
Excreta quality score	1.30	1.20	1.40	1.30	-

^{a,b} Means in the same row with different superscripts are significantly different (P < 0.05).

8.8.3 Feed efficiency (FCR)

Increasing levels of Mordenite had linear (P = 0.05) and quadratic (P = 0.01) effects on feed efficiency (Table 8.3). Inclusion of Mordenite to levels up to 5% had no effect (P > 0.05) on the feed efficiency of broilers. The inclusion of 2.5% Mordenite, however, caused a numerical improvement in feed utilisation (1.47 versus 1.51g feed/g gain). Feed efficiency was significantly (P < 0.05) depressed when 7.5% Mordenite was included in the diets.

8.8.4 Excreta Nitrogen content

Increasing dietary levels of Mordenite affected excreta nitrogen content in a linear (P = 0.001) fashion. Inclusion of 2.5, 5.0 and 7.5% lowered excreta nitrogen content by 8.0, 20.1 and 28.5%, respectively, compared to control birds.

8.8.5 Excreta Phosphorus content

Increasing dietary levels of Mordenite in broiler diets decreased excreta phosphorus contents in a linear fashion ($P = 0.001$). Inclusion of 2.5, 5.0 and 7.5% Mordenite lowered excreta phosphorus levels by 13.1, 16.1 and 30.0%, respectively, compared to the controls.

8.8.6 Manure quality and excreta moisture

Inclusion of Mordenite had no effect on excreta quality scores (Table 8.3). Moisture contents were lowered with increasing inclusion levels of Mordenite up to 5% inclusion. The inclusion of Mordenite in broiler diets had a linear ($P = 0.03$) effect on excreta moisture content.

8.9 Discussion

The objective of the present study was to investigate the influence of incorporating graded levels (0, 2.5, 5.0 and 7.5%) of Mordenite in a maize-soyabean meal diet on broiler performance and excreta quality. Although numerous studies have evaluated the use of natural zeolites in diets for poultry, all have used Clinoptilolite. To the author's knowledge, this is the first study evaluating the effects of Mordenite inclusion in poultry diets.

The present results showed that inclusion levels of Mordenite influenced the weight gain and feed efficiency of broilers. Inclusion of 2.5% Mordenite appeared to be beneficial, whereas performance was depressed at inclusion levels of 7.5%. The performance of birds fed diets with 5.0% Mordenite was similar to those on the control diet. Several reasons may be suggested for the growth response observed at 2.5% inclusion level. First, the natural zeolites have been shown to slow the rate of passage of feed through the digestive tract so that more time is available for digestion and absorption of nutrients and resulting in better feed efficiency (Lon-Wo *et al.*, 1987). Aluminium silicates present in zeolites are reported to be responsible for this mode of action (Evans *et al.*, 1990). Secondly, possible adsorption of undesirable components such as ammonia and mycotoxins by zeolites may also have contributed to the observed improvements. Ammonia in poultry rearing houses has been known to affect bird performance. When natural zeolites are added to feeds, many studies report reduced ammonia concentration in poultry houses. This action is likely due to the ability of the zeolites to bind endotoxins and gases by exchange reactions and to activate fermentation process (Evans & Farrell, 1993). As a result, the bound-substances pass through the bird without being absorbed.

There is conflicting evidence in the literature concerning the effects of zeolites on weight gain and feed efficiency (Willis *et al.*, 1982; Waldroup *et al.*, 1983; Dion & Carew, 1984; Evans & Farrell, 1990; Elliot & Edwards, 1991). Elliot & Edwards (1991) observed that natural zeolites improved the feed efficiency in broilers and left other parameters unaffected. This finding is supported by the study of Willies *et al.* (1982) who found that addition of clinoptilolites to broiler diets significantly improved feed efficiency. Willies *et al.* (1982) observed that addition of some zeolite deposits to broiler diets caused significant improvements in weight gains and feed efficiency, while Lon-Wo *et al.* (1987) also observed increased weight gain, feed efficiency and viability in broilers fed diets containing 5% zeolite. In contrast, others (Dion & Carew, 1984; Evans & Farrell, 1990; Evans & Farrell, 1993) observed no benefit of dietary supplementation of natural zeolites. As noted by Willis *et al.* (1982) many differences observed amongst these studies are related to the source of the natural zeolite and the level of impurities present in the individual samples.

The results of the current study on feed intake are in accord with other findings where addition of 5% zeolite had no effect on the feed intake of broiler (Lon-Wo *et al.*, 1987). The depressions in growth and feed intake observed at 7.5% Mordenite inclusion level may be as a result of gut fill effect or the nutrient dilution effect. It is also possible that, at high levels of inclusion, Mordenite may be binding some of the nutrients preventing their absorption.

Mycotoxin contamination is a major problem that can have adverse effects on poultry performance. These toxins occur worldwide contaminating wheat, maize, soyabeans and sorghum, which are normally used as poultry feed ingredients (Miazzo *et al.*, 2000).

The known effects of these substances include carcinogenicity, immuno-suppression, mutagenicity and teratogenicity (Ramos & Hernandez, 1997). Among all aluminosilicates tested with regard to aflatoxin adsorption, hydrated sodium calcium aluminosilicates (HSCAS) from natural zeolites has demonstrated an ability to adsorb mycotoxins (Ramos & Hernandez, 1997, Miazzo *et al.*, 2000). In New Zealand, locally grown maize is often contaminated with nivalenol (NIV) and deoxynivalenol (DON) due to excessive grain moisture at harvest and improper drying conditions. In such situations, zeolites can play a major role as mycotoxin binders, alleviating the detrimental effects of the toxins and improving bird performance. However, the analysis of the maize sample used in the present study showed no contamination with NIV and DON.

The diets used in this experiment were formulated to meet or exceed the recommended requirements for nutrients for broiler starter chickens according to NRC (1994). Some reports suggest that the beneficial effect of zeolite on bird performance is greater when raw materials of poor nutritive value are used (Lon-Wo *et al.*, 1987; Lon-Wo & Gonzalez, 1990; Castro & Lon-Wo, 1991). It is therefore possible that better broiler responses may have been obtained, if diets with lower protein and/or energy specifications were used in this study.

In broiler production systems, maintenance of litter dryness is critical. The main effect of excessive excreta moisture is the caking of the litter which can lead to a range of problems such as increased disease incidence, ammonia release and carcass condemnation. In this study, addition of Mordenite reduced excreta moisture in a linear fashion. This is in agreement with the findings of Nakaue *et al.* (1981) who observed a 17.4% reduction in litter moisture after adding clinoptilolite at the rate of 5 kg/m^2 in broiler pens. This moisture reduction was also associated with lower ammonia levels in the house. Ammonia levels, however, were not measured in the present study. The ability of Mordenite to reduce excreta moisture is probably related to its physical properties. These minerals are aluminium and silicon compounds with well defined molecular geometry and pores (full of water) connected in such a way that they form canals and cavities allowing the entrance and loss of water and the exchange of cations contained in their structure (Mumpton & Fishman, 1977). This finding, therefore, indicates that Mordenite adsorbs water molecules in the gastrointestinal tracts of birds. Under the New Zealand broiler production systems where birds are housed in environmentally controlled houses, the use of Mordenite will assist in reducing the excreta moisture and improve the poultry house environment.

Recently attention is being focused on intensive animal production systems as sources of nitrogen and phosphorus pollution threatening the quality of streams, estuaries and ground water resources (Kornegay, 1996; Nahm & Carlson, 1998). The results of present study showed that the inclusion of Mordenite in broiler diets reduces nitrogen and phosphorus levels in the excreta, and that has the potential to lower phosphorus environmental pollution in poultry units. Mordenite can be used both in feeds to reduce the excreta nitrogen and phosphorus levels and applied directly to poultry litter to reduce uric acid hydrolysis and ammonia levels in poultry sheds (Carlile, 1984).

The linear reduction in nitrogen and phosphorus content of the excreta of broilers with increasing dietary levels of Mordenite may be suggestive of improved utilisation of these nutrients. This possibility, however, is not supported by the absence of beneficial effects on broiler performance beyond the 2.5% inclusion level. Future studies should include nutrient retention evaluations.

9.0 Conclusions

It is concluded that the inclusion of 2.5% Mordenite in maize-soyabean based diets for broilers was beneficial in terms of bird performance. The observed depressions in weight gain, feed intake and feed efficiency at the 7.5% Mordenite level may be due to the dilution effect of nutrients by Mordenite as well as a gut-fill effect. Reductions in excreta moisture observed in Mordenite diets are indicative of the role that natural zeolites can play in maintaining litter quality. To my knowledge, this is the first study reporting the use of Mordenite in broiler diets. Overall, these preliminary findings are promising. Future studies should examine the effects of lower levels (less than 2.5%) of Mordenite inclusion in broiler diets and should include determination of nutrient retention.

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APPENDIX I

INSTITUTE OF FOOD, NUTRITION AND HUMAN HEALTH
MASSEY UNIVERSITY

Layer production systems in small-scale commercial farms in Botswana: A survey in the Francistown and Letlhakane Districts.

Code

1. **Demographic details**

i. Age in years (Circle one) [ ]1

1. 20-30 2. 31-40 3. 41-50 4. >50

ii. Gender: Male Female (Circle one) [ ]2

iii. Number in your immediate family: 2 3 4 5 6 7 8 (Circle one) [ ]3

iii. Number of years involved in poultry production? [ ]4

<2 years 2-5 years 6-10 years >10 years (Circle one)

iv. Level of education [ ]5

1. Primary 2. Secondary 3. Tertiary 4. Others (Name).

v. What special training in poultry production do you have? --------------------- [ ]6

vi. Years of schooling: 1. <7 2. 7-10 3. >10 years [ ]7

2. **How many birds are kept in the farm per year**? (Circle one) [ ]8

1. <500 2. 500 3. 501-600 4. 601-700 5. 701-800 6. 801-900 7. 901-1000

3. **What is the current age of your birds**? (Circle one) [ ]9

<20 weeks 21-56 weeks >56 weeks

4. **How many different age groups of birds do you have**? [ ]10

2 3 4 5 (Circle one)

5. **Replacement birds**

What is the age of your replacement birds? (Circle one) [ ]11

<18 weeks 20 weeks >20 weeks

How many replacement birds do you buy each year? (Circle one) [ ]12

1. <500 2. 500 3. 501-600 4. 601-700 5. 701-800 6. 801-900 6. 901-1000

6. **Breeds and their sources**

i. What breeds/strain of birds do you use? (Circle one) [ ]13

1. Lohman Brown 2. Hyline Brown 3. Others (Name)----------------

ii. Where do you purchase your birds? (Circle one) [ ]14

1. Locally through agents 2. Import directly 3. Others-----------------------

7. **Management systems**

i. What type of housing system do you use? (Circle one) [ ]15

Cages[1] Deep litter[2] Slatted Floor[3] Welfare[4]

ii. What type of heating system do you use? (Circle one) [ ]16

1. Gas 2. Coal 3. Others (Name)-----------

iii. Source of water for the birds (Circle one) [ ]17

1. Borehole
2. Dam
3. Standpipe
4. Others (Name)---------

iv. Feeds and their sources

What types of feeds do you use in your farm? (Tick one) [ ]18

1. Layer mash (Medium Energy) only
2. Layer mash (High Energy) only
3. Both

Do you provide any extra calcium for your birds? (Circle one) [ ]19

1. Yes 2. No

If yes what is the source? --------------- [ ]20

Where do you purchase these feeds? (Circle one) [ ]21

1. Locally through agents
2. Import directly
3. Locally made (Local mills)
4. Other

v. Number of birds per flock: [ ]22

1. <500 2. 500 3. 501- 600 4. 601-700 5. 701-800 6. 801-900 7. 901-1000

vi. Current flock size: [ ]23

1. <500 2. 500 3. 501- 600 4. 601-700 5. 701-800 6. 801-900 7. 901-1000

vii. How much feed do you give per flock? [ ]24

Layer mash (Medium Energy) ----------- kg

Layer mash (High Energy)--------- kg

viii. Current feed use per flock per day: <60 60 >60 kg [ ]25

ix. How many birds die in your flock? (Circle one)

Per month: 0-10 10-20 >20-30 [ ]26

Per flock: 30-40 40-50 >50-60 [ ]27

x. Which age group is the most affected? (Circle one) [ ]28

1. Pullet
2. Mid lay
3. Late lay
4. Other (Name)---------

xi. At what month of the year do you encounter more deaths? (Circle one) [ ]29

Jan. Feb. March April May June July Aug. Sept. Oct. Nov. Dec.

8. **Housing**

i. Type of housing used (Circle one) [ ]30

1. Open sided 2. Environmental 3. Others (Name)--------

ii. Number of birds per house (Circle one) [ ]31

1. <500 2. 500 3. 501- 600 4. 601-700 5. 701-800 6. 801-900 7. 901-1000

9. **Labour**

i. What percentage of labour is provided by: [ ]32

Family--------

Employed-----------

ii. What percentage of family labour is provided by? [ ]33

Women-------------

Children------------

10. **Diseases and their control**

i. What diseases are of importance in your farm? [ ]34

1. --
2. --
3. ---

ii. During what months of the year do these diseases occur most? [ ]35

Jan. Feb. March April May June July Aug. Sept. Oct. Nov. Dec.

iii. How do you control these diseases? [ ]36

1. Vaccination 2. No vaccination

vi. Do you use any disinfectants in your farm? [ ]37

1. Yes 2. No

v. Where do you purchase your drugs and vaccines? (Circle one) [ ]38

1. Livestock Advisory Centre

2. Private companies

3. Both

11. **Production Parameters**

i. How many eggs are produced on your farm? [ ]39

Per day ---------------

Per month -------------

ii. How many eggs are produced per flock (22 weeks to culling)? [ ]40

----

iii. How often do you collect eggs per day? (Circle one) [ ]41

1. Once 2. Twice 3. Other

iv. What percentage of the eggs is? [ ]42

Jumbo ------ Size 1 ------- Size 2 ------- Size 3 ------ Size 4 ------

v. In which month of the year do you get maximum egg production on your farm? (Circle one) [ ]43

Jan. Feb. March April May June July Aug. Sept. Oct. Nov. Dec.

vi. In which month do you get minimum egg production on your farm (Circle one)

Jan. Feb. March April May June July Aug. Sept. Oct. Nov. Dec. [ ]44

vi. During which months of the year do you experience increased egg cracks? (Circle one)

Jan. Feb. March April May June July Aug. Sept. Oct. Nov. Dec. [ ]45

vii. How do you store eggs before being sold? [ ]46

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viii. At what age do you cull your birds? [ ]47

<76 weeks 76-78 weeks >78 weeks

ix. What criteria do you use for culling (Circle one) [ ]48

1. Reduced number of eggs 2. Increased mortality 3. Other

12. **Sales and marketing**

i. How many eggs in total are sold per month? [ ]49

----

ii. Where do you sell your products? (Tick one) [ ]50

1. Locally 2. Outside 3. Others

iii. What percentage of your products is bought by? [ ]51

Wholesalers ----------

Retailers -------------

Others (Name)----------

13. **Income**

i. How much do you sell your eggs for? [ ]52

To Wholesalers ------------

To retailers ------------

Individuals -----------

14. **How much income do you earn per year from the sale of**: [ ]53

Chicken manure -------

Feed bags -------

Spent hens ------

Others (Name)-----

15. **Cost of production**

i. Total costs per flock of the following: [ ]54

Feeds ------------

Wages-----------

Vaccines and medication---------

Gas----------

Water-------

Egg cartons -------

Miscellaneous--------

Birds---------

ii. When did you purchase equipments and build your house? [ ]55

House----------

Equipments---------

16. **Government services**

i. How effective are services provided by the government? [ ]56

Very poor Poor Good Excellent

ii. What do you think about the courses provided to farmers in poultry production?

Very poor Poor Good Excellent [ ]57

iii. How could the services provided by the government be improved? [ ]58

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17. **Farmer attitude**

i. List any three problems that you encounter which affect your production. [ ]59

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ii. What do you think about the future of poultry production in Botswana? [ ]60

1. Poor 2. Good 3. Excellent

ii. Are there any cultural barriers towards your products? [ ]61

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18. **Any other comments** [ ]62

Thank you for the time you took out to answer this questionnaire. The confidentiality of your information is assured.

APPENDIX II

INSTITUTE OF FOOD, NUTRITION AND HUMAN HELATH
MASSEY UNIVERSITY

Broiler production systems in small-scale commercial farms in Botswana: A survey in the Francistown and Letlhakane Districts.

Code

1. Demographic details

i. Age in years (Circle one) [ ]1

1. 20-30 2. 31-40 3. 41-50 4. >50

ii. Gender: Male Female (Circle one) [ ]2

iii. Number in your immediate family: 2 3 4 5 6 7 8 (Circle one) [ ]3

iii. Number of years involved in poultry production? [ ]4

<2 years 2-5 years 6-10 years >10 years (Circle one)

iv. Level of education [ ]5

1. Primary 2. Secondary 3. Tertiary 4. Others (Name)

v. What special training in poultry production do you have? -----------------------[ ]6

vi. Years of schooling: 1. <7 2. 10 3. >10 years [ ]7

2. **How many birds are kept in the farm per cycle**? (Circle one) [ ]8

1. <500 2. 501-600 3. 601-700 4. >700

3. **Number of production cycles per year**? (Circle one) [ ]9

1 2 3 4 5

4. **What is the interval between the broiler cycles**? (Circle one) [ ]10

1. 2 weeks 2. 3 weeks 3. 4 weeks 4. 5 weeks

5. **How many batches of broilers do you have**? (Circle one) [ ]11

1 2 3 4

6. **Breeds and their sources**

i. What breeds/strain of birds do you use? (Circle one) [ ]12

1. Cobb 2. Hyline 3. Others (Name)----------------

ii. Where do you purchase your birds? (Circle one) [ ]13

1. Locally through agents 2. Import directly 3. Others-----------------------

7. **Management systems**

i. What type of bedding do you use? (Circle one) [ ]14

1.Wood shavings 2. Sawdust 3. Husks 4. Others (Name)

ii. What type of heating system do you use? (Circle one) [ ]15

1. Gas 2. Coal 3. Others (Name)-----------

iii. Source of water for the birds (Circle one) [ ]16

1. Borehole
2. Dam
3. Standpipe
4. Others (Name)---------

iv. Feeds and their sources

What types of feeds do you use in your farm? (Tick one) [ ]17

1. Broiler starter only
2. Broiler Finisher only
3. Both

Do you provide any other food type for your birds? (Circle one) [ ]18

1. Yes 2. No

If yes what is it? --------------- [ ]19

Where do you purchase these feeds? (Circle one) [ ]20

1. Locally through agents
2. Import directly
3. Locally made (Local mills)
4. Other

v. Number of birds per batch: 1. <500 2. 501-600 3. 601-700 4. >700 [ ]21

vi. Current batch size: 1. <500 2. 501-600 3. 601-700 4. >700 [ ]22

vii. How much feed do you give per batch? [ ]23

Broiler starter ----------- kg

Broiler finisher--------- kg

viii. Current feed use per batch: <2500 2500 >2500 kg [ ]24

ix. How many birds die in your batch? (Circle one)

Per month: 0-10 10-20 >20-30 [ ]25

Per batch: 30-40 40-50 >50-60 [ ]26

x. Which age group is the most affected? (Circle one) [ ]27

1. Week 1 2. Weeks 2 -3 3. Weeks 3-4 4. Other (Name)---------

xi. At what time of the year do you encounter more deaths? (Circle one) [ ]28

Jan. Feb. March April May June July Aug. Sept. Oct. Nov. Dec.

8. **Housing**

i. Type of housing used (Circle one) [ ]29

1. Open sided 2. Environmental 3. Others (Name)--------

ii. Number of birds per house (Circle one) [ ]30

<500 500 >500

9. **Labour**

i. What percentage of labour is provided by: [ ]31

1. Family 2. Employed

ii. What percentage of family labour is provided by? [ ]32

Women

Children

10. **Diseases and their control**

i. What diseases are of importance in your farm? [ ]33

1. ---

2. ---

3. --

ii. During what months of the year do these diseases occur most? [ ]34

1. January-April 2. May-August 3. September-December

iii. How do you control these diseases? (Circle one) [ ]35

1. Vaccination 2. No vaccination

vi. Do you use any disinfectants in your farm? [ ]36

1. Yes 2. No

v. Where do you purchase your drugs and vaccines? (Circle one) [ ]37

1. Livestock Advisory Centre

2. Private companies

3. Both

11. **Production Parameters**

i. How many birds are slaughtered on your farm? [ ]38

Per week ---------------

Per month -------------

ii. At what age are your birds slaughtered? -------------- [ ]39

iii. At what weight are your birds slaughtered ---------------------- [ ]40

iv. What is the average carcass weight achieved in your farm?--------------- [ ]41

iv. How often do you slaughter? (Circle one) [ ]42

1. Daily 2. Weekly 3. Other (Name)------

v. In which month of the year do you get maximum carcass weight on your farm? (Circle one) [ ]43

Jan. Feb. March April May June July Aug. Sept. Oct. Nov. Dec.

vi. In which month do you get minimum carcass weight on your farm (Circle one)

Jan. Feb. March April May June July Aug. Sept. Oct. Nov. Dec. [ ]44

12. Sales and marketing

i. How many birds in total are sold per month? [ ]45

----

ii. Where do you sell your products? (Circle one) [ ]46

1. Locally 2. Outside 3. Others

iii. What percentage of your products is bought by? [ ]47

1.Wholesalers ---------- 2. Retailers ------------- 3. Others (Name)----------

13. Income

i. How much do you sell your product for? [ ]48

1. To Wholesalers--------------

2. To retailers-------------------

3. Individuals------------------

14. **How much income do you earn per year from the sale of**: [ ]49

Chicken manure -------

Feed bags -------

Offal ------

Others (Name)-----

15. **Cost of production**

i. Total costs per batch of the following: [ ]50

Feeds ------------

Wages-----------

Vaccines and medication---------

Gas----------

Water-------

Miscellaneous--------

Birds---------

ii. When did you purchase equipments and build your house? [ ]51

House----------

Equipments---------

16. **Government services**

i. How effective are services provided by the government? [ ]52

1.Very poor 2. Poor 3. Good 4. Excellent

ii. What do you think about the courses provided to farmers in poultry production?

1. Very poor 2. Poor 3. Good 4. Excellent [ ]53

iii. How could the services provided by the government be improved? [ ]54

----

17. **Farmer attitude**

i. List three important problems that you encounter which affect your production. [ ]55

----

ii. What do you think about the future of poultry production in Botswana? [ ]56

1. Poor 2. Good 3. Excellent

iii. Are there any cultural barriers towards your products? [ ]57

----

18. **Any other comments** [ ]58

Thank you for the time you took out to answer this questionnaire. The confidentiality of your information is assured.