AN ASSESSMENT OF POULTRY FEEDS AND FEEDING REGIMES, THEIR EFFECTS ON GROWTH PERFORMANCE OF BROILERS IN URBAN AND PERI URBAN AREAS OF HARARE.

TOPODZI JONATHAN

B1130171

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AN ASSESSMENT OF POULTRY FEEDS AND FEEDING REGIMES, THEIR EFFECTS ON GROWTH PERFORMANCE OF BROILERS IN URBAN AND PERI URBAN AREAS OF HARARE.

BY TOPODZI JONATHAN (B 1130171)

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Approved by the department of Agriculture:
Mr. Washaya J. S (Main Supervisor) ...............................................................
Mr. Chikwanda A. T (Joint Supervisor)............................................................
ABSTRACT

A study was done on the feed types and feeding systems used by urban small holder poultry farmers in Harare. Adoption of commercial feeds was also assessed. A structured questionnaire was used to collect data including the demographic data of the farmers, chicken production related data, feeding systems related, feed production sources data and the flock healthy related data.

During interviews, feed samples were also collected and were tested for CP and CF using both dry and wet chemistry methods. Effects of variations on CP and CF for feeds from different production sources on weight at day 42 were assessed using linear regression model using Statistical Package for Social Sciences (SPSS) version 16.0. There was a significant difference on the weights obtained at day 42 between farmers using home-made and commercial diets (p<0.05) on Cobb 500, Hubbard and Ross chicks. Results from tests done showed that commercial feeds had higher CP values and lower CF values compared to home-made irrespective of the analysis method used. It was concluded that ingredients used in home-made diets should be analysed, their inclusion levels should be monitored, formulas they use should be revised, mixing procedures should be improved and essential amino acids, minerals and vitamins should be incorporated into home-made diets for them to perform as commercial feeds.

On effects of feeding regimes, there was significant difference on weight obtained by farmers using different feeding phases (p<0.05) for all the 3 breeds. The mean weight of birds on 2 and 3 phase feeding were significantly different from those on 4 phases (p<0.05). It was concluded that choice between 2 and 3 phase maybe based on cost, meat quality as their mean weight difference was not significant. The farmers were advised to start using 4 phase as it improves weight at day 42.

The adoption of commercial feeds was also assessed where farmers using home-made diets were the non-adopters. The binary logistic model was used to rank the independent factors or the predictor factors on predicting the adoption of commercial feeds. Sex, age and education were ranked as predictors of adoption using the odds ratios [Exp (B) > 0] and their B coefficient values showed that they were significant in predicting adoption (B>0). Marital status and density were also amongst the predictors in adoption of commercial feeds using odds ratios [Exp (B) > 0] but their B coefficient values showed that they were insignificant predictors (B<0). Religion have no relationship in predicting the adoption of commercial diets [Exp (B) = 0] and the B coefficient showed that it’s an insignificant predictor (B<0). It was therefore concluded that to improve the adoption of commercial feeds, males and those who have attained form 4 should be targeted as they have contributed more to odds ratios in predicting the adoption of commercial diets. In addition, though marital status, religion and density were not significant predictors, more emphasis can be done on married people, Christians and those living in high density suburbs as they were the most dominant groups doing urban poultry production.
DEDICATION

To

Topodzi family
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LIST OF ACRONYMS

AOAC = Association of Official Analytical Chemists
CDM = Cold Dry Mass
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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Livestock production makes significant contribution to the national Gross Domestic Product in Zimbabwe, amounting to US$357 million in 2012 (Central Statistics Office, 2012). It is also a source of employment, manure, household income, protein and many view it as a part time activity (Zimbabwe Poultry Association, 2012). Small stock also contribute to food security, improve human health through a more varied diet, alleviate poverty, contribute to the empowerment of women, children, the sick, disabled as well as other marginalized groups and it gives value to local feedstuffs that are normally not suitable for direct consumption by people (Mack et al., 2009 and Drakakis et al., 1995). Small animals have high rates of productivity and offer opportunities for regular cash inflow throughout the year. They ensure optimum use of the means of land, labour and capital. They can make excellent use of farm and industrial by-products (Jensen and Askov, 2009).

There is a growing need for feeding the growing urban population resulting from rural to urban migration in Zimbabwe (RUIF foundation, 2007). The requirement for animal protein has increased and has seen many urban people venturing into poultry production. The relevance of chicken has also increased owing to escalating beef prices that has seen many opting for chicken (Zimbabwe Poultry Association, 2012). Moreover, the business can easily be intensified and hence occupying little space reducing the complications for it to be done in urban areas. Naturally Zimbabweans are pro-agricultural and hence their desire for keeping poultry seems to be a mandate (Mlambo, 2000). An increase in the unemployment rate in urban areas makes poultry industry an important enterprise as it improves the lives of unemployed people. RUIF foundation (2007) added that the implementation of urban agriculture (UA) in Bulawayo is envisaged to alleviate poverty and provide food security for the Bulawayo urban community.

Small scale poultry production in urban areas of Zimbabwe has undergone major changes over the past decade adopting numerous scientific technologies in nutrition and health, vis-à-vis biotechnology. In nutrition, the use of additives such as enzymes, inoculants, antibiotics,
minerals and vitamins that are designed to improve digestion, live weight gain, liveability and reproductive performance have been adopted (Creswell, 2005). Others have started to formulate their own diets (Musamba, personal communication). Feeds in Zimbabwe are divided into two sources namely conventional (2, 3 and 4-phases) and home-made diets by utilising cereals and oil seed meals. The effects of adding additives like growth and intake stimulants continue to be debated in terms of human health (FAO, 2012). In poultry production, improved nutrition and health were identified as major pillars explaining the rise in productivity growth on studies on constraints affecting poultry competitiveness (Sukume, 2011).

Nutrition has remained a cost of economic importance to small scale farmers as it now swallowing up to 80% of the total broiler costs (Mpofu, 2004). In Zimbabwe, most farmer have been concentrating on conventional feeds that includes pre-starter, starter, grower and finisher diets though some of the farmers have started formulating their own feeds. Ready-to-feed commercial diets are becoming increasingly expensive due to the effects of recurrent droughts which reduce maize production (Dhliwayo, 2011). This decrease in maize production leads to an increase in the price due to a sharp rise in demand, as maize is also a staple crop to many families (Dhliwayo, 2011). According to Sonaiya (2011) small scale poultry producers have used simple ingredients such as wheat bran, maize germ meal, soya meal, sunflower meal, crushed maize and limestone flour in their feed formulations. Luis et al. (2004) added that other small holder use raw soya beans, sunflower seeds, sorghum seeds and maize grain in supplementing their broilers though he argued that they will not supplement enough nutrients for broiler requirements.

The two and three phase feeding systems have been widely used in Zimbabwe and were proved efficient by achieving 1.6kg and 1.8kg cold dry mass (CDM) at 6 weeks (Poultry site, 2011). However, other large poultry farmers have already started using the four phase programme where chicks are given pre-starter crumbles from day one until day ten before proceeding to starter crumbles. Irvines’ Zimbabwe as one of the big companies using the four phase, it have achieved 1.65kg in 28 days arguing that this regime produces birds with tender meat and accepted by many customers especially the food outlets and hotels (Irvine’s, 2011). The performance of broilers has been associated with lower grower rates for small holder farmers as proposed by breeders. Despite the fact that poultry production is increasing, there is an apparent increase in the level of feeds being re-processed after reaching their expiry dates in depots (Feed Matters, 2013). This is puzzling, given that day old chick producers claim that
there is an increase in the number of clients who are now into chicken production (Zimbabwe Poultry Association of Zimbabwe, 2012), yet there is no corresponding statistics in stock feed consumption from Feed Mills. There is need to assess where the majority of the chicken farmers (65 %), who are small scale urban chicken producers obtain their feed or what they are using to feed their chickens and categorising the phase they prefer.

The use of different poultry feeds and poultry regimes have raised debates in relation to their effects on growth rates and mortality rates in broilers (Pond *et al.*, 2005). In dealing with these issues, wise decisions on choosing a feeding regime to use and farmers ability to follow instructions for that regime were emphasised in the Ross manual (2007). Feed Matters (2011) added that three phase system produces better growth rates as compared to two phases since it produces enough proteins and energy for each level of growth.

### 1.2 Problem statement

Lower growth rate in broilers have been experienced by most smallholder farmers in Harare (Musamba, personal communication). This is increasingly becoming more difficult to maintain total feed consumption below 3.5kgs /35 days in order to reach an average of 1.8kg live weights as proposed by most feed mills. Hence has increased the feed costs well above the expected averages of 70-80% of total costs (Mpofu, 2004). As a way of improvising, other small holder farmers have opted to use home-made rations (Musamba, personal communication). This has also lead to the use of a wide array of conventional feeds with variations in nutritive values from renowned suppliers and reprocessing of certain diets is now being experienced. In addition, the use of non-conventional feeds with unknown nutritive values is increasing in broiler smallholder farmers. Non-conventional feeds need to be documented and have their nutritive values tested using standard procedures. Due to lack of adequate market; feed mills have produced excessively large volumes of feed that is beyond the farmers’ consumption.

### 1.3 Justification of study

Low growth rates of broilers kept by urban smallholder broiler farmers are a serious cause for concern. The broilers are taking too long to attain the required market weights. The urban broiler farmers end up giving more feed to the broilers than what is normally consumed to complete the cycle. As a result, feeding costs shoot up well above 70-80% averages. Some farmers have therefore, have resorted to formulation of own feed to substitute commercial feeds. Homemade feeds usually lack consistence in the available nutrients (Sonaiya, 2008).
Some farmers may not be knowledgeable on the nutritive values of the ingredients they use and they are danger of compromised performance.

The question remains, why not attaining target weight set by breeders? This has raised the need for collecting and analyzing raw materials as well as final feeds formulated by farmers. In a bid to help quantify the causes of reduced weight gain, there is need to collect samples of different feeds from different sources and use scientific procedures to observe their imperative nutritive capacity. Nevertheless, there is need to verify whether possible variations on crude protein and crude fibre of different marketed broiler feeds are causing variations on slaughter weight at day 42. Reprocessing of feed is superficial in an economy with a booming broiler industry. Hence, there is need to categorize the preferred feeding phase by the majority of urban smallholder broiler producers and elucidate the reasons that might cause re-processing of certain diets. Considerable dynamics of feeding phases can result in different nutritive values and costs. Hence, weights at day 42 are varying. The outcome of this research might help explain causes of reduced weight gain in broilers based on scientific analysis of feed types, feeding materials and production sources. At the same time, the results can mitigate the reasons behind increased reprocessing by feed producers as a way to increase efficiency.

1.4 Main objective

The main objective of the study is to assess the nutritive values of homemade feed stuffs and compare them to commercial rations as well as determining their effects on broiler performance.

1.4.1 Specific objectives

- To evaluate the nutritive composition (CP and CF) of different feed sources and their effects on the 42 day weight of broilers.

- To assess the effects of using different feeding regimes on the weight of broilers at day 42 for Harare poultry producers.

- To assess the rationale behind farmer preferences and adoption of feed resources between home-made and commercial diets.

1.5 Hypotheses

Null Hypothesis 1

There is no difference on the nutritive composition of different feed sources and their effects on 42 day weight in broilers.
Null Hypothesis 2

There is no difference on weight at day 42 from broilers fed using different feeding regimes.

Null Hypothesis 3

There are reasons behind the adoption of either home-made or commercial diets

CHAPTER TWO

2.0 REVIEW OF LITERATURE

2.1 Introduction to Broiler Production

Chicken production in Zimbabwe comprises of keeping broilers, layers or indigenous chickens (Mapiye et al., 2008). Broilers (Gallus gallus domesticus) are specially bred birds with the
ability to grow fast, they take more feed voluntarily, are quick at feathering, have a good conformation, they are well covered with muscles and also convert feed very effectively (Ugwu, 1990). Encyclopaedia Britannica (2007) added that in urban areas broilers are kept as pets and are acting as a great tool for teaching youngsters responsibility by allowing them to be actively involved in the process. Broilers in Zimbabwe are also kept as a source of protein, income and as a part time activity by other people (ZPA, 2012).

In terms of poultry development, production rates in Zimbabwe have shown tremendous recovery and growth from an all-time low in January 2009 with the adoption of multiple foreign currencies (Central Statistics Office, 2012). The day old chick production in the first quarter of 2009 was 160 000/week and continued to show linear recovery to date (CSO, 2012). It was added that day old chick production in 2010 averaged 721600/week, exceeding the previous peak achieved in 2000 of 720 200/week. Day old chick production in the first nine months of 2011 exceeded production attained in 2010. The recovery and expansion has been spurred by resuscitation and expansion of established breeders as well as entry of new breeders with a total hatch capacity of 1 432 800 chicks/week.

In Zimbabwe three day old chick breeds are used namely Cobb 500 which are obtained from Irvine’s, Hubbard flex at Hubbard breeders and Ross chicks which are obtained as Chinyika chicks, Fivet chicks, Supa chicks, Charles Stewart’s Ross amongst others. The most common stock feeds manufacturers includes Natfoods, Novatek, Profeeds, Windmill, Agrifoods, Capital foods, R T feeds, Hyperfeeds, Feedmix, Bascom feeds and Fivet (Feed Matters, 2011). Despite the presence of these feed manufacturers and day old chick suppliers in Zimbabwe, the market demands for chicken are reaching up to 12 000 tonnes per month and hence local farmers are failing to beat the demand. According to Zimbabwe Poultry Association (2012), the country is allowing an import quota of up to 500mt per month from countries like South Africa, Brazil and USA amongst others.

Poultry production presents an efficient alternative to meet animal protein needs of the nation because of its rapid growth and short generation cycle (Luis et al., 2004). It has played a vital role to meet the gap in animal protein supply at cost effective prices in Zimbabwe during the last 3 decades. At present, the industry is facing feed crisis because of high cost of production attributed to scarcity of cereal grains, high costs of importing non GMO soya from India and Zambia as well as minerals, vitamins and amino acids from Germany (National Foods Article, 2013). The fact that feeding cost constitutes 70-80% of the total cost (Mpofu, 2004) and are
even increasing in broiler farming due to an increase in feeds is eroding the returns in broiler production (Hubbard, 2013). Protein and energy are the major nutrients for poultry feed formulation as their sources take up to 30% and 60% respectively in diet formulation formulas (Creswell, 2005). When fed adlibitum from day old to finishing, broiler birds attain just above 2 kg live weight to reach 1.8kg CDM at about 6 weeks (Creswell, 2005). However, other researchers recommended dietary restriction. They argue that restriction has the welfare benefits of enhancing physical health (such as walking ability), increases growth rates by compensatory growth, enables utilisation of excess fat and avoids their deposition, mitigates metabolic disease and prolong lifespan as well as reducing cases of heart failure and ascites [Richards et al. (2010), Darre, (2011) and Luis et al. (2004)].

The introduction of broilers in Zimbabwe is not well documented but is believed to have started by a few large scales farmers well before independence (Kusina et al., 2001). Scoones et al. (2012) argued that though broilers were kept at a very small scale in urban areas, the scale have been increasing since independence and is still growing seeing 50% of day old chicks from hatcheries being taken by small scale producers. Rose et al. (2007) also argue that broilers are omnivorous animals that can be grown under intensive conditions and hence it’s possible to keep them in urban areas. Feighner and Dashkevicz (2010) agreed that urban farmers are concentrating more on typical broilers that have white feathers, yellowish skin than any other breeds.

Lack of employment in the main cities of Zimbabwe have increased back-yard poultry production in the lower middle-class hence acting as an instrument of social justice and poverty alleviation (Mack et al., 2009). This has raised a need to evaluate the success of the urban poultry and critically examine the poultry feeding materials and regimes to avoid unnecessary losses by analysing the nutritive values of these feeds as well as strengthening decisions. According to Lilburn (2007), raw materials like sunflower meal have been decorticated to improve digestion and soya bean have been roasted to eliminate anti-nutritional factors. Mpofu (2004) added that oil extraction of soya bean and cotton seed also generated heat that removes the effects of anti-nutritional factors. Other small holder farmers are relying on home-made rations though they don’t know the nutritive values of these feeds. Hence need for analysing the feeds, identifying methods to improve digestibility and correct feeding programs remain in isolation seeking attention at both small scale and commercial levels.
Feeds are usually analysed for CP and CF as well as calcium as they are growth determinants and their levels regulate voluntary feed intake. In Zimbabwe feed analysis is done mainly using two methods namely the dry and wet chemistry (Feed Matters, 2011). Use of machines like the near infrared reflectance (NIR) which are accurate, rapid and produce correct estimates in 6 seconds is becoming a common dry chemistry method all over the world. The Kjeldhal method is one of the traditional methods used for analysing for CP and the alternate acid and alkali treatments have been used for analysing for CF (AOAC, 1990).

According to Stockfeed Manufacturer Association (2013), a successful nutrition plan can assist in reducing losses in broiler production by increasing weight gain and reducing days to maturity, increasing batches reared per annum thereby maximising returns on every dollar invested. Researches on the feeding programs used in broiler production has been on-going for decades, most of them have been concentrating on 2-phase program since the 3 and 4-phase were not common in Zimbabwe (Poultry site, 2011). It was added that the growth rates of broilers under 3 and 4 phase systems have been done only under experimental conditions and their effects under farm conditions have not yet been extensively assessed. The development of innovative ideas for improving poultry feeding requires a complete understanding of the system and its key players (Hooshmand, 2006). In Zimbabwe, there is limited reliable information on feeding systems, poultry genetics, lighting programs, nutritive values of feeds and feeding materials used in poultry production and hence there is need to concentrate on these aspects (Kusina et al., 2001).

2.2 Keys Aspects to Successful Broiler Production.

2.2.1 Advantages of broiler production over other livestock species.

The initial investment and capitalisation of broiler production is lower than other animal enterprises like layer, beef, dairy farming and a short rearing period of about 5-8 weeks (Creswell, 2007). Jensen and Askov (2009) added that more batches can be reared over a short period of time, requires a small piece of land and broilers have high feed conversion efficiency making it possible to be done in urban areas. ZPA (2012) and on the Poultry Site (2011), it was agreed that the demand for poultry meat is high and hence easy to market as compared to sheep, goat and pig meat which are more associated with religious taboos. Broiler farming can be a main source of family income and gainful employment to farmers throughout the year since it is not highly affected by seasons as the environments they require are a little bit easy to manipulate for (Dolberg and Petersen, 2005). According to Rose et al. (2007), poultry manure
has high fertilizer value and can be used for increasing yield of all crops and hence it’s an enterprise that can be mixed with crop production.

2.2.2 Characteristics of a good broiler site.
Site selection of a fowl run is an important factor and availability of sufficient land to enable future extending of the enterprise need to be considered (Chikwanda and Chikwanda, unpublished). Preferably higher land are used to avoid water logging which is associated with fungal diseases is a appropriate though good drainage systems have catered for this problem in urban areas. A permanent, clean water supply is needed since water need to be changed at least three times a day due to the fact that broilers do not consume slippery water and are easily affected by dehydration especially in hot weather (Bennert et al., 2009 and Lilburn, 2007). Moreover, water is needed for washing houses at the end of every production cycle. In urban areas tanks, sinks, tubs, swimming pools amongst others have been used as water reservoirs due to massive water cuts. Good road connectivity, electricity for heating and lighting are very important factors in broiler production (Sukume et al., 2012 and Jensen et al., 2000). Though susceptible to more power cuts, electricity for lighting and heating have not been a major problem in most urban areas of Zimbabwe. Irvines’ Zimbabwe (2011) recommends that when constructing fowl run in Zimbabwe, the east and west directions must be covered with solid walls to avoid pathogens carried by wind drafts as well as direct sunlight and hence the other two remaining sides are covered with wire mash for aeration. However, in urban areas garages and internal rooms have been used as brooding houses in urban areas (Mbibai, 1995). After the brooding period, broilers are transferred to other houses that might be constructed with wood or solid bricks. Hence there is a clear need to investigate the performance of broilers under such improvised structures and feeding schemes to see how they differ with the standards.

2.2.3 Preparation of placement of chicks
Fig 2.1 showing basic needs of a broiler (Darre, 2011)
Activities that are done before chick arrival include thorough cleaning, spraying sanitizers and fumigating the brooder houses (Mercia, 2010). This is done to remove dirty from previous batches and excess gases like ammonia (Bennet et al., 2009). Cleanliness has been taken seriously in low density suburbs compared to high density suburbs (Drakakis et al., 1995). After thorough cleaning, disinfection with virakill is necessary to kill pathogens and hence avoiding transfer of diseases from one batch to another (Paxton et al., 2010). Infrared lamps are used for supplementing heat and electric bulbs are used for lighting to enable feeding at night and bedding of soft, dry wood shavings should be 5cm thick in summer, 10cm in winter (Broiler Management Guide, 2008). Fine shavings or sawdust is not recommended for litter as the chicks may pick up the small particles and die due to gizzard impaction (Sukume and Maleni, 2012). Zimbabwe Poultry Association (2012) added that the brooder house corners should be circular to avoid crowding and huddling of chicks in corners which is one of the factors which contribute to chick mortality. Placing of water troughs and feeding troughs 2m apart in the brooder house is done 24 hours before chick arrival and egg trays have been widely used to supplement chick feeding troughs since they expose the feed well (Cobb Breeder Management Guide, 2005).

Preparations and activities that are done on the day of chick arrival include mixing of water and vitamin stress pack at a rate of 100g/200litres for drinking 2-3 hours before feeding chicks with broiler starter mash or crumbles (Cresswell, 2005). Moreover, adding some sort of sweetener substance like sugar to the water (4% solution) for the first few hours of life is important. The sugar helps to replenish the depleted energy in the chicks during transportation and may stimulate the chicks to consume feed (Noya and Sklan, 2011). The sweet water can also loosen up the impacted intestine and prepare the gut linings for the incoming feed. Eliana and Balcazar (2010) argued that delayed access to feed impairs not only intestinal development or chick weight shrinkage but also development of gut-associated lymphoid tissue (GALT) like the bursa of fabricius, caecal tonsils and meckel's diverticulum. Mercia (2010) added that farmers physical count and check for deformities, weakness and sickness to separate these chicks from the healthy ones. On automated systems, weighing is done and the average weight is recorded. Few chicks will be trained how to drink by dipping their beaks into the drinking troughs and how to feed by winnowing a little bit of some feed in the air and then the rest will copy from other (Ross Manual, 2007).
The broiler manager should strive to achieve the required flock performance in terms of live weight, feed conversion, uniformity and final meat yield. In the first two weeks of life developing appetite and immune function in a broiler flock is critical (Broiler management guide, 2009). This requires particular attention and therefore, chick handling, brooding and early growth management are all of great importance (Luis et al., 2004 and Bennett et al., 2009). A broiler chick should be able to gain four times its post-hatch body weight by seven days of age ( Hubbard, 2013 and Madriga et al., 1994). The fact that broiler production is a sequential process, ultimate performance is dependent on the successful completion of each step and meeting specified targets (Noy and Sklan, 2011). They added that each stage must be assessed critically and improvements made wherever required. This maximises performance in developing the skeleton and cardiovascular system thereby optimising carcase quality. Feed analysis and digestibility trials are essential to address questions related to the nutritive value and digestibility of raw materials, final products, inclusion rates as well as degree of processing that might be necessary (Sonaiya, 2011).

The ideal temperature for the brooding area for broiler chicks should be 32°C (90°F) with the heat source being placed at least 18 inches above the floor and temperature readings taken at chick height (Hooshmand, 2006). Chikwanda and Chikwanda (unpublished) added that pre-warming the brooder to achieve this ideal temperature is essential. A National Foods article (2013) added that a thermometer is hanged in the house, at a point furthest away from the heat source at chick height. Both Ross Manual (2007) and Profeeds feeding manual (2013) emphasised that reducing the temperatures by 3°C (5°F) every week is recommended until the ideal temperature of 21°C (70°F) is reached. Cobb broiler management guide (2008) added that the chick behaviour is the best temperature indicator amongst all and if they are huddled (they are too cold), if they are panting or are crowding near the brooder guard (they are more than likely too hot). The flock needs to be evenly spread over the area to show correct temperatures.

2.2.4 Health management
In poultry health the primary emphasis is given more on prevention and control than curative measures, hence a suggestive disease prevention and control programme which start with disease free stock should be implemented (Dolberg and Petersen, 2005). Vaccinating chicks against Ranikhet (New castle) and Marek’s disease at hatchery, keeping feed free from aflatoxins is of paramount importance (Mercia, 2010). The use of chick mash or prestarter crumbles with coccidiostat to prevent coccidiosis is recommended (Noy and Sklan, 2011). In
Zimbabwe, usually visitors or outsiders are not allowed inside the poultry premises in big companies like Irvine’s and Hubbard breeders unless they wear disinfected boots and clean protective clothing to avoid the transmission of disease causing organisms.

The Storey’s guide to raising chickens (2010) pointed out that floors must be covered with clean, dry litter or wood shavings at least 3 inches deep in order to keep them warm in cold environments, for comfort reasons and absorbing excess moisture. The litter need to be properly managed because it can pollute the pen with ammonia which damages the chickens’ eyes and respiratory systems (Sukume 2011). He argued that heavier birds are affected more as they spend longer times resting causing painful burns on their legs (called hock burns) and foot ulcerations. Moreover, Creswell (2007) and Rose et al. (2007) agreed that all-in-all out system of rearing broilers is recommended as it ensures minimum disease problems or cross infections between different batches. In addition to suitable management, other factors that reduces moisture level in the brooder houses include avoiding excessive levels of crude protein in diets, avoiding high salt/sodium levels as this will increase bird water intake and causes wet litter, avoiding using poorly digestible or high fibre feed ingredients in the diets, providing good quality feed fats/oils in the diet. All these factors help in maintaining good litter quality (FAO, 2012).

According Mack et al. (2009) the feed, housing, rodents, water, wild birds, other poultry, livestock and pets, people, litter, insects, hatchery management, equipment and vehicles remains elements of disease exposure. In dealing with issues of health, bio-security remains the key aspect and is composed of three major components which are Isolation, Traffic Control and Sanitation (Ross manual, 2007). Bio-security measures include fencing, keeping visitors to a minimum, keeping wild birds out of poultry houses, practicing sound rodent and pest control programs, inspecting flocks daily and recognizing disease symptoms as well as good ventilation and relatively dry litter (Poultry site, 2011). More so, keeping areas around houses off grass and feeding bins clean, proper disposal of dead birds, using disinfected and sanitised poultry house and equipment need attention (National Research Council, 1994). Bio security is one of the areas that are ignored by urban small holder farmers as some of its components are not applicable in case of farmers that raise birds in residential areas.

The general management like checking birds daily for signs of disease as well as getting a reliable diagnosis and treatment are necessary (Broiler management guide, 2009). Culling very sick or injured birds, using proper disposal methods (burning or burying deep), establishing a
regular de-worming program, replacing wet litter and proper disposal of manure such as composting aid in controlling diseases (Bennett et al., 2009). Table 2.1 below shows vaccinations programme followed by most commercial farmers in Zimbabwe. This has been ignored at small scale but however, chemicals like Terramycin, Terranox, ESB3 and Oxytetracycline have been used at both small and commercial levels (Mapiye et al., 2008).

Table 2.1 showing a vaccination programme followed in Zimbabwe

<table>
<thead>
<tr>
<th>DISEASE</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marek’s</td>
<td>1st day</td>
</tr>
<tr>
<td>Ranikhet (f-strain)</td>
<td>5th day</td>
</tr>
<tr>
<td>Gumboro/ IBD</td>
<td>7-9th day</td>
</tr>
<tr>
<td>Gumboro/ IBD (booster dose)</td>
<td>16-18th day</td>
</tr>
<tr>
<td>Ranikhet (f-strain)</td>
<td>30th day</td>
</tr>
</tbody>
</table>

Adopted from Mapiye et al. (2008) and Kusina et al. (2001).

2.3 Feeding Schemes and Regimes in Broiler Production

The objective of a defined feeding program is to supply a range of balanced diet that satisfy the nutrient requirements of broilers at all stages of their development and that optimize efficiency and profitability without compromising bird welfare or the environment (Leksrisompong et al., 2006). Due to the reason that different age groups require different nutrients, broiler feeds have been classified into different classes depending on age to be given (Hooshmand, 2006). The regimes used in Zimbabwe are 2 phase (starter and finisher), 3 phase (starter, grower, and finisher) and 4 phase (prestarter, starter, grower, and finisher) regimes (SMA, 2013).

Ration formulation for all the regimes requires availability of appropriate feedstuffs, analysis of feedstuff composition, knowledge of the nutritional needs of chickens and the ability to mix feed in quantity your flock will use within four weeks (Pond et al., 2005). They also argued that manufacturers must produce different standards per age group which should be followed when feeding.
When farmers adhere to proper feeding techniques, chicks usually increase their weight four to five times in the first six weeks of life and this tremendous growth demands proper nutrition (Lilburn, 2007). To ensure proper skeletal and muscular development as well as healthy gains, a fully balanced diet must be fed to chicks and levels of calcium to phosphorus, CP, CF and fats should be considered. Eliana and Balcazar (2010) agreed that starter and pre-starter products must be used in early broiler life time. Lack of nutritionally balanced ration causes poor feathering, slow growth, increased fatness and leg problems (Noy and Sklan, 2011 and Madrigal et al., 1994). In another text, Luis et al. (2004) argued that use of poorly digested ingredients in feeds significantly lowers the growth rates and this cannot be corrected by providing grits or sand to chicks. Jensen and Dolberg (2009) added that conditions such as easy access to feed, clean water, vaccine, vaccinations services contributes positively to poultry business.

In small holder farmers, the use of 3-phase feeding programme have been associated with challenges as lack of funds to purchase the feed, unable to follow the lighting programmes, overfeeding the birds leading to ascites, heart problems and sudden death (Zimbabwe Poultry Association, 2012). These have caused a resistance in terms of adopting the 3 and 4 phases hence a greater percentage are still using the 2 phase. However, most commercial farmers are criticising the 2-phase saying that it requires more than 7 weeks to achieve a weight of 2.5kg live weight which can be attained within 7 weeks when using the 3-phase programme or even less when using 4-phase.

In the analyses supported by UNICEF, Feighner and Dashkevicz (2010) have however strongly questioned the effects of biotechnology and enhancers as well levels of synthetic amino acids included in the pre-starter given in the 4-phase on agricultural productivity growth, poultry welfare and household food security. The issues on proper space, odour, noise, pests, diseases and housing have controversially raised complications to broiler production in urban areas (Mack et al., 2009 and Ranichauri, 1999). However, understanding the national and regionally-disaggregated movements in animal production in terms of how raw materials are being manipulated for easy digestion, how chickens are housed to reduce noise as well as odour, how to control pests and diseases, proper ways of disposing waste and how other supplements added to feeds over time is a critical component step in clarifying such discussions (Mapiye et al., 2008).
2.3.1 Two phase programme

The two phase programme is commonly used in Zimbabwe (ZPA, 2012), where the first 3 weeks of life, a broiler consumes an average of 1.5kg of broiler starter diet which can be in form of crumbles or mashes. From day 21 the broilers are given broiler finisher diet up to slaughtering and consume an average of 2.5kgs (National foods article, 2013). In the 2 phases, the starter diets have a higher protein and lower energy level comparing with the finisher diet shown by table 2.2 below. Hubbard (2013) pointed out that a smaller chick does not have a fully developed GIT and hence requires a nutritive diet in terms of proteins and hence must be formulated from easily digestible and palatable raw materials. It is the most common phase followed by farmers in Zimbabwe even those who make their feeds. It was the first regime that was developed by nutritionists in trying to provide required nutrients at each stage of life (NRC, 1994). However, it was criticised and lead to the development of another diet to be given the starter and finisher diets in-between to adequately satisfy each stage. The standards below are the same with those targeted by Zimbabwean stockfeed companies (SMA, 2013).

Table 2.2 showing the standard requirement of nutrients in 2 phases:

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Starter</th>
<th>Finisher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Protein % target</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>Crude Fibre % max</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Calcium % max</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Phosphorus % max</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Metabolizable energy k/ca/kg</td>
<td>2800</td>
<td>2900</td>
</tr>
<tr>
<td>Lysine % max</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Methionine % max</td>
<td>0.35</td>
<td>0.35</td>
</tr>
</tbody>
</table>

Adapted from (BIS Standards 2007)

2.3.2 Three phase programme

Table 2.3 showing Protein and energy targets for Broilers under 3 phases.

<table>
<thead>
<tr>
<th>Targets</th>
<th>0-2 weeks Starter</th>
<th>2-4 weeks Grower</th>
<th>4-6 weeks Finisher</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>21%</td>
<td>20%</td>
<td>18%</td>
</tr>
<tr>
<td>ME (kcal/kg)</td>
<td>3,200</td>
<td>3,200</td>
<td>3,200</td>
</tr>
</tbody>
</table>
Leksrisompong et al. (2006) recommends that broiler farmers targeting 1.8 kg CDM at 6 weeks of age must use the 3-phase feeding system where commercially prepared broiler starter, grower, and finisher are used. According to Hubbard (2010), these targets can be reached at 5 and half weeks when using controlled houses. A coccidiostat is usually added in the starter and grower diets though cleanliness remains the most important factor in eliminating coccidiosis. Lilburn (2007) added that following feed supplier or veterinarian's recommendation for coccidiostat in the finisher is advised. Moreover, following a lighting programme is recommended to avoid overfeeding the birds and heart problems to the chicks (Profeeds feeding manual, 2013). In this phase, a broiler chicken will consume an average of 0.9 kg of starter, 1.5 kg of grower and 1.4 kg of finisher for 6 weeks or alternatively can consume 3.5kg for 5 weeks (National foods article, 2013).

### 2.3.3 Four phase programme

This programme involves the beginning of the feeding with the prestarter crumbles that are more digestible and nutritive than the starter crumbles (Noy and Sklan, 2001). In Zimbabwe, broiler producers like Irvine’s and its contract farmers uses this feeding programme. Four phase feeding system have produced better weights that 2 and 3 producing about 1.65kg in 28 days (Irvines, 2011). Broilers are bred for fast growth have a high incidence of leg deformities because the large breast muscles cause distortions of the developing legs and pelvis and the birds cannot support their increased body weight (Eliana and Balcazar, 2010). It was observed that these cases increases when using 4 phases as it enables broilers to fully express their genetic potential (Saki et al., 2010). Therefore, they may become lame or suffer from broken legs. The added weight also puts a strain on their hearts, lungs and exposing birds at risk from ascites (Hooshmand, 2006).

<table>
<thead>
<tr>
<th>Prestarter</th>
<th>Starter</th>
<th>Grower</th>
<th>Finisher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (days)</td>
<td>Day 1-7</td>
<td>8 - 21</td>
<td>22 - 35</td>
</tr>
<tr>
<td>Feed (kg)</td>
<td>0.15kg</td>
<td>0.9 kg</td>
<td>1,8kgs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,1kgs</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.4 below showing the 4-phase and average amount of feed expected to be consumed
Table 2.5 showing nutrition composition in the four phases

<table>
<thead>
<tr>
<th>Parameters (minimum levels)</th>
<th>Pre Starter</th>
<th>Starter</th>
<th>Grower</th>
<th>Finisher</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME poultry MJ/kg</td>
<td>12,18</td>
<td>12,49</td>
<td>13,02</td>
<td>13,22</td>
</tr>
<tr>
<td>Raw protein %</td>
<td>22,55</td>
<td>21,03</td>
<td>20,30</td>
<td>19,04</td>
</tr>
<tr>
<td>Lysine %</td>
<td>1,31</td>
<td>1,22</td>
<td>1,15</td>
<td>1,08</td>
</tr>
<tr>
<td>Methionine %</td>
<td>0,60</td>
<td>0,59</td>
<td>0,53</td>
<td>0,50</td>
</tr>
<tr>
<td>Threonine %</td>
<td>0,86</td>
<td>0,80</td>
<td>0,77</td>
<td>0,72</td>
</tr>
<tr>
<td>Tryptophan %</td>
<td>0,25</td>
<td>0,23</td>
<td>0,23</td>
<td>0,22</td>
</tr>
<tr>
<td>Raw fibre %</td>
<td>3,43</td>
<td>3,21</td>
<td>3,34</td>
<td>3,41</td>
</tr>
<tr>
<td>Raw fat %</td>
<td>4,07</td>
<td>4,65</td>
<td>7,06</td>
<td>7,47</td>
</tr>
<tr>
<td>Calcium %</td>
<td>0,96</td>
<td>0,95</td>
<td>0,90</td>
<td>0,85</td>
</tr>
</tbody>
</table>

Adapted from National Academy of Sciences (1994).

2.3.4 Five phase programme

According to Provimi, they normally recommend a five phase feed program for the different stages of the birds. The nutrient levels of the complete feed per phase differ depending on circumstances, such as the availability and prices of raw materials where imports are likely to be limited their inclusions. They also pointed out that inclusion rates also depends on the company goals, such as lowest cost per kg of meat, maximum daily gain or lowest feed cost per kg feed or per bird. However, this has not been used in Zimbabwe yet.

Table 2.6 below shows the Provimi five phase feeding system

<table>
<thead>
<tr>
<th>Age (days)</th>
<th>Prestarter</th>
<th>Starter</th>
<th>Grower</th>
<th>Finisher 1</th>
<th>Finisher 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 1 - 6</td>
<td>7 - 14</td>
<td>15 - 28</td>
<td>29 - 37</td>
<td>38 up to slaughter</td>
</tr>
<tr>
<td>Feed (kg)</td>
<td>0.1</td>
<td>1</td>
<td>1.2</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>
2.4 Broiler Diets and Products

Poultry complete feed is composed of 60-65% energy giving materials, 30-35% of protein source and 2-8% minerals source in its formulation (Poultry site, 2011). The sources of energy that have been used include maize up to 60%, maize germ up to 10%, sorghum (Milo) up to 45%, wheat up to 25% and with enzyme up to 45%, wheat by-products (bran, shorts, screenings) up to 15%, rice by-products (bran, polishing) up to 15%, barley up to 15% and with enzyme up to 35%, molasses up to 5% for diets given after 2 weeks and water. For protein sources soybean meal up to 30%, soybeans up to 15% (heated to remove anti-nutrients), sunflower meal up to 10%, fish meal up to 10% blood meal and feather meal up to 2% (BIS standards, 2007 and Sonaiya, 2011).

Water which is considered as the principal nutrient should be pure, whole some, free from physical impurities, toxic substances and bacterial contamination. The recommended water to feed ratio is 2.2: 1 respectively (Creswell, 2007). Though poultry need sufficient nutrients, too much of other nutrients have caused metabolic disorders such as ascites, sudden death syndrome (SDS) and leg problems (Broiler management guide, 2009). In general, people have associated such conditions with rapid growth, thus various feeding programs have been recommended in an attempt to reduce the incidence of these problems (Jensen and Askov, 2000).

2.4.1 Pre-Starter Products

The fact that, the anatomy and physiology of young chicks differs significantly from that of older broilers raises the issue of producing prestarter products (Cobb broiler management guide, 2008). This marks the period when chicks are being transformed from embryonic absorption of yolk to utilisation of feed which is accompanied by dramatic changes in the digestive tract (Eliana and Balcazar, 2010). Hence need palatable feeding materials. Noy and Sklan (2011) added that in the first few days after hatching, the length and weight of the proventriculus, gizzard, liver, pancreas, and intestine (duodenum, jejunum and ileum) increase in size almost four times quicker than the body as a whole and hence requires feed with high digestibility.

A strong positive correlation exists between first week live weight and finishing weight at the end of production cycle that intensify the importance of a good start for ultimate better performance in commercial broilers (Irvine’s Zimbabwe, 2011). Adequate protein availability
in the pre-starter phase (min-22.5%) seems to be essential to increase muscle development in later phases (Ross manual, 2007)

The use of special pre-starter products, some of which contain more digestible raw materials, have been shown to be effective in promoting early development of broilers and improving subsequent processing performance (Creswell, 2005). Such products are often of superior physical quality and provide a feed intake response. The Ross manual (2007) pointed out that the pre-starter products increases feed costs in 4 phases though they are only used for the first few days of life when feed intake is still relatively low. Therefore, they have only a small impact on overall cost of production. Generally, there is a positive response in margin achieved as a result of improved overall broiler performance and increased revenue (Aviagen, 2007).

Some features of Pre-Starter products are listed below:

- Use of highly processed and digestible ingredients which are more palatable.
- Use of pre- and pro-biotics.
- High nutrient levels, especially amino acids, vitamin E and zinc.
- Addition of immunity stimulants; essential oils or nucleotides.
- Inclusion of intake stimulants; feed form, high sodium and flavours.

### 2.4.2 Broiler Starter Feeds

The starter should contain a coccidiostat to stop intestinal damage caused by one of the common types of chicken parasites. The objective of the brooding period which is the first 14 days of age is to establish good appetite and achieve maximum early growth (Cresswell, 2007). The target is to achieve a seven-day body weight of 170 g or above (Hubbard, 2013). Most companies in Zimbabwe target a range of 19-23% crude protein to allow the bird to achieve maximum early growth (SMA, 2013). The starter represents a small proportion of the total feed cost and decisions on starter formulation should be based on performance and profitability rather than cost. Total fat levels should be kept low (<5%) and saturated fats should be avoided, especially in combination with wheat as they reduces feed intake (Luis et al., 2004).

Early nutrition plays a vital role in early life and productivity of broilers (Creswell, 2007). Noy and Sklan (2011) argued that maximum growth occurs in the first week of broiler’s life (takes approximately 20% of total). A strong positive correlation exists between first week live weight
and finishing weight at the end of production cycle that intensify the importance of a good start for ultimate better performance in commercial broilers.

2.4.3 Broiler Grower Feeds
Broiler grower feed will normally be fed for 14 to 16 days (Ross manual, 2007). The transition from starter feed to grower feed will involve a change of texture from crumbs to pellets though manufacturing companies also produce grower crumbles (Profeeds feeding manual, 2013). There is a continuing need for a good quality grower feed to maximise performance and 20% of crude protein is targeted (Stockfeed Manufacturer Association, 2013). If any growth restriction is required, it should be applied during this period to avoid over feeding the birds that lead to heart problems and ascites. Use of management techniques, like meal feeding or lighting to restrict feed intake, is preferred (Champion Feed Services, 2009). However, growth restriction by diet composition is not recommended.

According to the Aviagen Ross Poultry Breeders (2009), unrestricted feeding is related to growth rate that increases body fat deposition, mortality and incidence of metabolic diseases and skeletal disorders. These situations most commonly occur with broilers that consume feed adlibitum. Thus feed restriction has been proposed to reduce these problems (Balcazar and Eliana, 2010).

2.4.4 Broiler Finisher Feeds
Broiler finisher feeds account for the major cost of feeding and economic principles should be applied to the design of these feeds. Changes in body composition can be rapid during this period and excessive fat deposition and loss of breast meat yield need to be carefully considered (Aviagen, 2007). The broiler finisher feed targets a lower protein level of about 19% due to the fact that a smaller increase in weight will be expected compared to the fat that will be required for marbling (Creswell, 2005).

The decision whether to use one or two broiler finisher feeds will depend on desired slaughter weight, the length of the production period and the design of the feeding programme (Ross Poultry Breeders, 2009). Withdrawal periods for drugs may dictate the use of a special withdrawal finisher feed. This feed should be adjusted for the age of the birds but the practice of extreme nutrient withdrawal during this period is not recommended.
2.5 Feed Resources Used By Small Holder Farmers

A complete feed is a prepared ration that contains all of the nutrients like the protein, calcium, potassium, phosphorus, salt, fibre and other minerals as well as the vitamins for the physiological growth and development in poultry (Poultry Site, 2011). These feeds in Zimbabwe are usually produced commercially by feed manufacturers like Agrifoods, National foods, Profeeds and Capital foods amongst others. On average a broiler is expected to consume a protein level of about 20 to 24% in its early life (day 1 up to day 14) and a grower with protein ranging from 18% to 20% at day 14 to day 21 and or a finisher with protein ranging from 17% to 19% and higher in energy at day 21 until ready for market (Zimbabwe Poultry Association, 2012). However, materials used by small holder farmers as poultry feed are usually not tested for nutritive composition. Concentrates can also be prescribed by feed mills which require mixing with cereals like sorghum or maize to produce the starter and finisher diets. Hence mixing ratios are provided by the manufacturer.

Apart from these commercial feeds, small holder farmers are using other feed resources such as the soybean seeds, sunflower seeds, wheat bran, crushed maize, maize germ and red sorghum seeds in poultry feeding (Mapiye et al., 2008). Gadzirayi et al. (2012) categorized them as cereals for energy and oilseeds for proteins. These feed resources are either fed directly to poultry or they can be used as raw materials for feed formulations.

2.5.1 Soybean seeds

In Zimbabwe, 50 000 smallholder farmers are currently growing soya beans which are mainly used for oil and stock feed production (Zimstats, 2008). In stock feed manufacturing, soybeans are used as ingredients for protein in three forms, the mature dry roasted seeds (Soy nuts), full fat soya extruded under pressure with the presence of heat and soya meal obtained after mechanical extraction of oil (Heuser, 2013). Small holder farmers, however use raw soybean seeds to feed their poultry. FAO (2011) added that their inclusion need to be limited to maximum inclusion levels of about 30% citing that they have an imbalance of nutrients especially amino acids like methionine, the presence of anti-nutritional factors as the trypsin inhibitor, urease, phytoestrogens and lectins hence can reduce the feed general palatability.

Creswell (2005) added that small birds are more susceptible to anti-nutritional factors and hence use of raw soya beans in formulating their diets must be avoided. As mentioned on the Poultry site (2011), Mogridge et al. (1996) observed that use of raw soya increases the size of the pancreas and the duodenum decreasing the feed intake and growth by a significant
percentage. Though raw soya beans are associated with anti-nutritional factors, Knabe and Tanksley (2006) argued that it is rich in calcium and magnesium that will be sufficient to home raised meat chicken. They also raised an alarm to the world on the amount of poly unsaturated fatty acids found in soya beans arguing that it reduces the general feed intake of broilers and hence their inclusion levels should be less than 30% in any formulae. The Poultry site (2011) added that Summers et al. (1966) have discovered that the chickens fed with 20% untreated beans grew by 24% less and had a conversion of 11% worse than the control chickens fed with soybean meal and fat. He added that raw beans reduced the consumption of the feed (88 vs. 101 g/day), laying capacity (53.8 vs. 79.0%) and egg size (58.1 vs. 61.7 g).

It is argued that mechanical and heat treatments can also be used to process the seed to reduce the effects of these anti-nutritional factors. In addition to the fact that processing is required, World Poultry (2009) argued that the duration exposed to heating also influences the goodness of the final product and define its nutritional value to a large extent. More recently, commercially available enzymes have been developed to improve the digestion of non-starch polysaccharides in soybeans for pigs and poultry. According to the Poultry Site (2011), Saxena et al. (1963) argued that soybeans can be roasted using the traditional fire until they turn dark brown or auto cleaved using an oven between 100-130°C for about 25 to 30 minutes at a small scale to deal with anti-nutritional factors. Boiling raw soybeans for 30 minutes was reported to result in satisfactory performance in broilers and laying hens, even at up to 35 percent of the diet (Chen et al., 2011). Gadzirayi et al. (2012) argued that soybean can be replaced by mature Moringa oleifera leaf meal and concluded that up to 25% inclusion of this supplement can attain similar weight gain as conventional feeds.

### 2.5.2 Sunflower seeds

Sunflower (*Helianthus annuus*) is a fast-growing cash crop grown primarily for its oil as well as a protein supplement in poultry and ruminants (Pond et al., 2005). At a small scale Doli et al. (2006) noted that the mature seeds can be supplemented without any processing though he argued that they will be having too much fat and oil. In dealing with this Lilliboe (2005) added that mechanical pressing or solvent extraction can be used to extract excess oil. Mack (2009) added that mechanical pressing leaves up to 13% oil in the meal which is still too high for poultry as it reduces feed intake and he urged that the solvent extraction should be used which leaves oil as low as 1%. 
Sonaiya (2008) observed that most small holder farmers ignore dehulling as they view it as wasting though he argued that this improves the nutritive value as well as the palatability of sunflower meal in poultry diets. He also observed that sunflower meal is richer in the sulphur-amino acids than soya bean meal although its lysine and threonine are much lower causing some restrictions in formulation of non-ruminant feed rations. Luis et al. (2004) added that the process of dehulling or decortication results in a sunflower meal with protein levels above 30% and fibre levels of 21% and below. There are known phytotoxins present in the sunflower plants though there is no strong evidence that they are also found in its mature seeds (Doli et al., 2006). The maximum amount of sunflower meal that can be included in diets for broiler chicks appears to be 15 percent in all mash diets and 30 percent in pelleted diets (BIS standards, 2007). Sunflower meal has been successfully been used at levels of up to 20% in broiler and layer diets, but complete substitution of Soyabean meal resulted in lower productivity and feed conversion (Stockfeed Manufacturer Association, 2013).

2.5.3 Wheat bran

Wheat bran consists of the outer layers (cuticle, pericarp and seed coat) combined with small amounts of starchy endosperm of the wheat kernel that has a fairly high protein and fibre content as well as mineral and vitamins; hence it has a laxative effect when fed at excessive levels to poultry (Sonaiya, 2011). Wheat bran is believed to contain pentosans which are thought to have anti-nutritive activities in poultry and result in depressed nutrient utilization and poor growth. Luis et al. (2004) argued that though it has a higher fibre content, wheat bran has a high phytate activity which increases the availability of phosphorus in poultry. He also argued that it contains a very heat-stable lipase which causes hydrolytic rancidity and is more active when the bran is finely ground. Rose et al. (2007) argued that wheat bran is necessary as it is insoluble and hence passes through the gastrointestinal system aiding digestion, adding bulk to stools and preventing constipation. However, too much wheat bran in a formulation results in pellets with poor water stability due to the water absorption characteristics of fibre. The wheat bran produced in Zimbabwe has an average well above 15% crude protein and an average of around 5% fat (Feed Matters, 2013).

2.5.4 Maize meal and maize germ

Maize (Zea mays) also known as corn and is one of the cereal crop that is used for feed formulations in poultry. Maize grains contain the highest energy content of all the major cereals and approximately two-thirds of the grain is starch, which is readily digested by monogastric
animals (Sonaiya, 2008). Its inclusion rate is even up to 60\% of the feed ration formulas that are used in Zimbabwe (Feed Matters, 2013). Besides providing energy, maize meal helps in reducing constipation of feed in poultry especially when using mashes.

One of the important by product of dry maize milling is maize germ meal which is comprised of mainly the external testas. It contains a crude protein level from about 10-25\% and oil level which ranges from about 5-10\%, fibre of 4.5-10\% and a starch content around 23\% (Feed Matters, 2013). The amount of the oil and the fibre reduces its inclusion in poultry feed rations since it is not allowed to exceed 10\%.

2.5.5 Sorghum seeds

Sorghum ( *Sorghum bicoloris* ) seed in general contains an average of 70\% starch, so is a good energy source. Sonaiya (2008) argued that it have a lower energy level than maize as its starch consists of 70 to 80\% amylopectin, a branched-chain polymer of glucose which has a very low digestibility and 20 to 30\% amylose, a straight-chain polymer which is the one digestible. Thakur *et al*. (2008) added that it contains anti-nutritional factors such as tannins and the presence of tannins is claimed to contribute to the poor digestibility of sorghum starch. In Zimbabwe sorghum is rarely used due to the fact that its grown at a very small rate and its costs in terms of importing is higher compared to using our local maize (Poultry site, 2011). In diet formulations, Dhliwayo (2011) concluded that substituting maize with sorghum by up to 40\% would not adversely affect broiler performance and hence there is need to substitute maize for sorghum if available.

CHAPTER 3

3.0 MATERIALS AND METHODOLOGY

3.1 Study Area

The research was done in Harare province which lies in the agro-ecological Region II b receiving an average of 600 mm to 1000 mm of rainfall per annum. The mean temperature ranges from 19-28°c. Region II is suitable for intensive farming systems for both crops and livestock. Most residents in Harare are now backyard broiler producers and there is a variety of feed manufacturing companies with depots distributed all over the province. Due to these
poultry production activities, chicken houses and pens have been constructed within the residential areas.

3.2 Experimental design
Data collection was done via formal interviews conducted through structured questionnaires. For the broiler smallholder farmers to interview, names and the details of the broiler farmers in Harare were obtained from different feed manufacturing companies. Frequent buyers of stock feeds and day old chicks were nominated and a total of 120 farmers were obtained. A third of these farmers were randomly selected by hat picks coming up with a sample population size of 40 farmers who were interviewed. The structured questionnaires designed in English language were pretested at one of the stock feed producing companies. The questionnaires were then distributed in person to the targeted respondents who were poultry farmers in urban and peri-urban areas in Harare.

3.3 Sampling procedure
Table 3.1 Stock feeds depots for each company around the Harare province.

<table>
<thead>
<tr>
<th>Natfoods</th>
<th>Profeeds</th>
<th>Novatek</th>
<th>Windmill</th>
<th>Agrifoods</th>
<th>Capital feeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lytton</td>
<td>Woolwich</td>
<td>Makoni</td>
<td>Lomagundi</td>
<td>Remembrance</td>
<td>Southerton</td>
</tr>
<tr>
<td>Ruwa</td>
<td>R Manyika</td>
<td>Southerton</td>
<td>M Nehanda</td>
<td>R Manyika</td>
<td>Ruwa</td>
</tr>
<tr>
<td>Seke</td>
<td>Irvines</td>
<td>Ruwa</td>
<td>Coventry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspindale</td>
<td>Show</td>
<td>Bluff hill</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mbare</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boka</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Selection of peri-urban and urban farmers was done by randomly selecting a depot by hat pick for each stockfeed company (National foods, Novatek, Profeeds, Windmill, Agrifoods and Capital feeds). The depots which were used for selection of one representative for every company are shown in the table 3.1 above. For every company, all its depots in Harare shown by table 3.1 above were labelled on different equal sized piece of papers and placed in a hat. After complete mixing by shaking, one paper was picked to represent that particular manufacturing company. The selected depot then provided a list of its regular customers with available contact details. The 120 customer names which were obtained from the representative depots were then arranged in alphabetical order and then a minimum of 40 customers randomly
chosen by hat picks. The customers which were provided by the feed mill depots included the feed customers and day old chick customers.

3.4 Measurements

The data that was generated from the questionnaire included demographic data of the farmer, chicken production related data, feeding systems related data and the flock healthy related data shown by appendices 1. The broiler live weight obtained at day 42 by every farmer interviewed were weighed and recorded. Moreover, details on the types of feeds used (whether conventional or non-conventional), the cost of feeds used, the feed production sources (Home-made, Novatek, National foods, Pro-feeds, Agri-foods, Windmill and Capital foods) were obtained. The feeding regimes followed and the adoption of commercial feeds was also assessed. On the conventional and non-conventional feed samples collected, the crude protein content were measured using the near infrared reflectance machine (NIR) and the Kjedahl method. The crude fibre content of the diets was analyzed by the NIR as well as the alternating heating and cooling with both an acid and alkali.

3.5 Data collection

A questionnaire was used to collect the data from the representative sample of 40 small holder farmers. Personal interviews were conducted answering different questions; samples were collected to fulfil requirements for other objectives as described below:

3.5.1 Chemical analysis

Samples on types of feed offered to chicks (home-made or conventional) were collected from farmers during interviews. A 200g feed sample was collected from every farmer. A total of 32 samples were collected and amongst them 11 were broilers starter samples, 8 were grower samples and 13 were finisher samples. The pelleted samples were thoroughly mixed by grinding them using the grinding machine before thorough shaking. After complete mixing, the dry chemistry (NIR) was used for both CP and CF (Blake, 2011). On wet chemistry Kjeldhal method was used for CP and alternate acid and alkali treatment for CF (AOAC, 1990).

Methods of Analysing For CP and CF Content

Dry chemistry

The DA 7200 Near Infrared Reflectance machine was used for scanning the samples for both CP and CF. The process was divided into three steps. Firstly a sample was poured into two
open aluminium dishes; strike off excess sample using a ruler to be levelled before placing the dish under the light beam. A product in line with the type of feed to be analyzed was then selected from the list displayed on the screen. The products displayed on the screen were within the calibrated database of the machine. After selecting the product, pressing enter was done to scan the first dish before placing the second dish for completing the analysis of that sample.

**Wet chemistry- Kjeldhal method for CP.**

This method was divided into three steps, which were digestion, neutralisation and titration. On digestion, 1g of the grounded and homogenously mixed samples was firstly weighed using an electronic balance into 500-800ml Kjeldhal flasks. They were then mixed with 10g of a catalyst that was made up of a mixture of sodium sulphate, copper sulphate and selenium powder, heated in the presence of 30ml sulphuric acid for an hour using heating mantles protruding into the fume cupboard. After a complete hour of heating with constant turning, the flasks were cooled in a running sink for 15 minutes. After losing all the heat, the digest was then transferred to 250ml volumetric flasks and top up to the maximum level with tap water.

Afterwards, 25ml of the cooled samples were then pipetted into Hoskins flasks together with 25ml of 50% sodium hydroxide for neutralisation. The samples were then steam distilled into a conical flask containing 15ml of a mixture of boric acid and the mixed indicator. Shortly after the volume in the conical flask passed the 50ml mark, the flasks were removed from the Hoskins distillation apparatus and titrated with standardized 0.01N sulphuric acid. The colour changed from green to purple. The titre or the amount of sulphuric acid used to change the digest colour from green to purple (Nitrogen value) was used in calculating the percentage crude protein using formulae below:

\[
\text{% Protein} = \frac{\text{Blank - Titre} \times 6.25 \times 1.401}{\text{sample weight}}
\]

**Wet chemistry-alternate treatment with acid and alkali for CF**

The method was divided into 2 digestions and 2 filtrations. Firstly, excess fats were removed by defating the samples with three washings using 25ml portions of hexane. For first digestion, 3g of defatted samples were measured using the analytical balance and transferred it into 1-litre long neck conical flasks. 200ml of boiling sulphuric acid (1.25%) were added into the flasks and attach the cold finger condenser. The contents were boiled and continued refluxing was done gently for 30minutes from the onset of boiling using the condenser. The flasks were rotated at 5 minutes intervals to prevent samples from adhering to the sides of the flask. At the
end of the acid digestion, the contents were filtered from the flask with suction onto a filter paper (N° 541 or 1505) fitted to a Buchner funnel. The sample left in the flask was removed by rinsing it down with portions of hot water. Washing the filtrate was done using 50-100ml of boiling water. Repeated washing was done until the samples were no longer acidic. The samples were washed back into the digestion flask with 200ml of hot Sodium Hydroxide (1.25%). The contents were boiled again for 30minutes and the flasks were kept rotating by shaking at 5 minutes intervals.

The samples were filtered with suction through a Whatman filter paper (N° 541), fitted to Buchner funnel and boiling water was used for rinsing. The samples were washed with boiling water until the samples were no longer basic and the residues were transferred into porcelain crucibles using a spatula. The samples were dried in an oven at 130°C for 2hours and were cooled to room temperature in a desiccator. The weights of the crucible + residue were recorded. The samples were ignited in a muffle furnace at 550°C to 600°C for 3hours before cooling them in a desiccator to room temperature and weighing them after cooling.

**CALCULATIONS**

(a) % Crude Fibre on as fed basis = \( \frac{\text{Loss of weight on ignition} \times 100}{\text{Weight of sample before drying and oil extraction}} \)

(b) % Crude Fibre on DM Basis = \( \frac{\% \text{ Crude Fibre on as fed basis} \times 100}{\% \text{ Dry Matter of as fed basis sample}} \)

After obtaining values, the data was captured in the Microsoft excel aligning with the source of the feed and the method of analysis. The analysis of variations in CP and CF were done using a linear regression model which was as follows:

\[ Y_{ij} = \mu + F_i + A_j + e_{ij} \]

Where:

\( Y_{ij} \) = response variable being crude protein and crude fibre values

\( \mu \) = generalized mean

\( F_i \) = effect of feed source \( i = 1, 2, 3, 4, 5, 6, 7 \)

\( A_j \) = effect of analysis method used \( j = 1, 2 \)

\( e_{ij} \) = experimental error
The effects of feeds from different feed sources and their nutritive values (CP and CF) on weight at day 42 were analyzed by the following general linear regression model where breed was used as a blocking factor:

\[ Y_{ijk} = \mu + B_i + T_j + e_{ij} \]

Where:

\[ Y_{ij} = \text{response variable being weight at day 42} \]
\[ \mu = \text{generalized mean} \]
\[ B_i = \text{effect of blocking (} i = 1, 2, 3) \]
\[ T_j = \text{effect of treatment (} j = 1, 2) \]
\[ e_{ij} = \text{experimental error} \]

3.5.2 Questionnaire survey on feeding regimes
The feeding regimes followed by the farmers were also identified and were categorized into 2, 3 and 4-phase feeding systems. For every farmer, 42 day live weight obtained by the regime used were also captured and recorded. The information was captured in the Statistical Package for Social Sciences (SPSS) version 16.0. The analyses of variance between different feeding regimes on weight at day 42 were captured in the general linear model with breed as a blocking factor on the following equation:

\[ Y_{ijk} = \mu + B_i + P_j + e_{ijk} \]

Where:

\[ Y_{ij} = \text{response variable being weight gain at day 42} \]
\[ \mu = \text{generalized mean} \]
\[ B_i = \text{effect of blocking (} i = 1, 2, 3) \]
\[ P_j = \text{effect of feeding regime used (} j = 1, 2, 3) \]
\[ e_{ij} = \text{experimental error} \]

3.5.3 Questionnaire survey on adoption of commercial diets
The farmer preference on feed source and adoption of commercial feeds were also identified. The commercial feeds were categorized into six groups namely the Pro-feeds diets, National
foods diets, Agri-foods diets, Capital foods diets, Novatek and Windmill diets. Amongst the farmers interviewed, all farmers using commercial feeds were categorized as adopters and those using home-made feeds were categorized as non-adopters. For those categorized as adopters, their preferences on cost and adoption of the commercial diets were assessed by binary logistic regression equation:

\[ Y_{ijk} = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + e_{ijk} \]

Where:
\[ Y_{ijk} = \text{farmer preference and adoption of commercial diets} \]
\[ B_0 = \text{constant} \]
\[ X_{1i} = \text{is the odds ratio of choosing commercial over home-made feeds using site of residence (i = high, low)} \]
\[ X_{2i} = \text{is the odds ratio of choosing commercial over home-made feeds using sex (i = male, female)} \]
\[ X_{3i} = \text{is the odds ratio of choosing commercial over home-made feeds using marital status (i = married, single, widowed, divorced)} \]
\[ X_{4i} = \text{is the odds ratio of choosing commercial over home-made feeds using age (i = < 20 yrs, 21-30yrs, 31-40yrs, 41-50yrs, >50yrs)} \]
\[ X_{5i} = \text{is the odds ratio of choosing commercial over home-made feeds using highest level of education (i = no formal education, grade 7, form 4, form 6, diploma, degree)} \]
\[ X_{6i} = \text{is the odds ratio of choosing commercial over home-made feeds using religion (i = Christianity, Muslim, traditional)} \]
\[ \exp(B) = \frac{p}{1-p} \text{ odds ratio = probability of occurrence ÷ probability of not occurring} \]
\[ e_{ijk} = \text{error term} \]

**CHAPTER 4**

**RESULTS AND DISCUSSION**

There was no significant difference on the values of CP and CF obtained irrespective of the method of analysis used (p>0.05). There were slight differences on the results obtained from wet and dry chemistry methods for same samples from the same production sources. Castro (2006) argued that the near infrared reflectance (NIR) is a modernized machine that accurately estimates the nutritive value of a sample as long as it is correctly calibrated with true nutritive values of the raw materials to be used. Foss (2013) added that the NIR is accurate in determining the CP and CF levels as their structures are made up of carbon backbones. Donald and Emil (2007) agreed that NIR is most suitable machine which uses infrared waves to
estimate the organic compounds in feeds as they are viewed at different wavelengths. According to Blake (2011), wet chemistry results are the most accurate methods of analyzing feeds since there is no need for complex calibrations though human error can distort the results. He added that errors in measurements and preparations of reagents and solutions are the most common ones. Foss (2013) and Castro (2006) agreed that the results of NIR and Kjeldhal method shows slight differences for protein levels in feeds and hence the NIR can replace the Kjeldhal method since it is a fast method. From the analyses that were done, the results shows that the variations between the wet and dry chemistry values for CP and CF might be by chance, hence these two methods are equally important.

Table 4.1 showing average nutritive values of samples collected

<table>
<thead>
<tr>
<th>Production source</th>
<th>Average Crude Protein</th>
<th>Average Crude Fibre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Starter</td>
<td>Finisher</td>
</tr>
<tr>
<td>Home-made</td>
<td>18.3%</td>
<td>16.6%</td>
</tr>
<tr>
<td>Commercial Windmill</td>
<td>N/S/a</td>
<td>18.41%</td>
</tr>
<tr>
<td>Commercial Agri-foods</td>
<td>20.99%</td>
<td>18.88%</td>
</tr>
<tr>
<td>Commercial Capital foods</td>
<td>N/S/a</td>
<td>18.90%</td>
</tr>
<tr>
<td>Commercial Novatek</td>
<td>22.01%</td>
<td>N/S</td>
</tr>
<tr>
<td>Commercial National foods</td>
<td>21.65%</td>
<td>18.85%</td>
</tr>
<tr>
<td>Commercial Profeeds</td>
<td>23.9%</td>
<td>20.33%</td>
</tr>
</tbody>
</table>

The table above is showing the mean CP and CF values from different production sources amongst farmers interviewed. The mean values were calculated by computing results for farmers using the feed from the same production source. NB For N/S/a, no samples were available.

There was significant difference on the CP and CF values from different production sources at 5% significant level (p<0.05). The CP values from commercial feeds were higher than the home-made rations. From the assessments and observations made, commercial diets were made up of highly processed protein ingredients like extruded full fat soya, mechanically extracted soya meal and sunflower meal, highly processed animal protein sources like the fish, blood, feather and meat or bone meals. In comparison, it was observed that most small holder farmers uses raw sunflower and under processed soya bean seed meals as major protein sources. Chen et al. (2011) argued that oil extraction in soya beans and sunflower seeds are essential in raising CP and reducing high lipid values. It was observed that amongst all farmers using sunflower meal, only one farmer physically extracts oil from the sunflower seed before using it for feed formulation. Supplementing amino acids like glycine, methionine and lysine is necessary when using sunflower meal as it improves the nutritive value of feeds in terms of CP content (FAO,
2011). This was only done for commercial diets as individual farmers failed to import them. Amongst farmers who were using soya bean seeds, two processing methods were identified where one Epworth farmer roast them until they attain a brown colour and the Glennorah farmer who roast them in an oven at 100°C for 30 minutes though this was done at a minute scale. Chen et al. (2011) argued that if roasting soya bean before using them is done properly, it can only cater for anti-nutritional factors but will not raise protein levels by significant levels. Lilliboe, (2005) added that dehulling the sunflower seeds increased the quality of proteins in poultry feeds. Amongst farmers interviewed, no farmers dehulled their sunflower during the process of producing their sunflower meals. This might have contributed to their lower levels of CP.

In addition, the CF values of commercial feeds were lower than home-made rations. The use of sunflower that is not dehulled has significantly increased the CF in home-made feeds. Moreover, higher inclusion levels of cheap ingredients like wheat bran, maize germ meal and sorghum seeds amongst others have increased CF content in home-made diets. In terms of commercial feeds, the use of bran have been limited to as low as 5% inclusion levels and not allowed to exceed 10% and have been mixed with enzymes to improve their utilisation (BIS standards, 2007 and Sonaiya, 2011). SMA (2013) added that commercial feed manufacturers in Zimbabwe must not exceed 10% CF as it is not allowed by animal welfare. This is however, not considered at farm or household formulation levels. These lower inclusion levels of highly fibrous materials in commercial diets might have reduced the CF content as compared to homemade diets.

On multiple comparisons within homogenous groups, the Tukey’s HSD mean differences of CP content of Novatek and Pro-feeds diets were significantly higher at 5% significant level than those of Agri-foods, Capital foods, National foods and Windmill (p<0.05). Due to the reasons that different companies uses different raw materials, of different nutritive values, with different formulas and inclusion levels, this might causes variations in the nutritive values of the final products. Moreover, differences in the quality monitoring departments, levels of extensive researches and technical staff can lead to differences in quality of feeds produced. Given the increasing number of people venturing into poultry business, there is no doubt, that there is a high demand for commercial feeds (Central Statistics Office, 2012). Hence there is an assumption that other feed manufacturers tend to produce substandard feeds, especially as the quality control agencies are non-existent or non-functional.
Table 4.2 showing CDM average weights attained at day 42 using different feed sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Combined Mean weight (kg) at day 42</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home-made</td>
<td>1.471c</td>
<td>0.29</td>
</tr>
<tr>
<td>Commercial Windmill</td>
<td>1.70b</td>
<td>0.12</td>
</tr>
<tr>
<td>Commercial Agri-foods</td>
<td>1.75b</td>
<td>0.15</td>
</tr>
<tr>
<td>Commercial Capital foods</td>
<td>1.75b</td>
<td>0.15</td>
</tr>
<tr>
<td>Commercial Novatek</td>
<td>1.86a</td>
<td>0.72</td>
</tr>
<tr>
<td>Commercial National foods</td>
<td>1.86a</td>
<td>0.51</td>
</tr>
<tr>
<td>Commercial Profeeds</td>
<td>1.88a</td>
<td>0.47</td>
</tr>
</tbody>
</table>

The mean weight values with different superscript are significantly different using the Tukey’s HSD at 5% significant levels.

There was significant differences on the weight attained at 42 days using feeds from different production sources (p<0.05) in all the three breeds. The weights attained by farmers using commercial diets were higher than those using home-made diets.

The level and efficiency of production of any animal depends on the provision of adequate protein, energy, vitamins and minerals in the right proportions in their diets (Pond, 2005). As shown by the tests that were done, CP for commercial diets was higher than home-made diets. Hence they are likely to produce better growth rates to Cobb 500, Hubbard flex and Ross chicks as supported by the results. Amino acid addition is essential in feed formulation as it increases the precursors for protein synthesis. Saki et al. (2010) added that protein deposition in cells is one of the determinants of growth. Moreover, optimum levels of protein found in the commercial diets are the most suitable for poultry as they need up to 21% CP at early stages of life and up to 18% CP at late stages (NRC, 1994). These levels are optimum for muscle development, repairing of damaged tissues and all post natal growth processes (Creswell, 2005). Though lower CP levels retard growth, very higher levels stresses the kidney through filtering and diamination of excess proteins (Knabe and Tanksley, 2006). Lilburn (2007) added higher CP predisposes the birds from necrotic enteritis, physiological need for increasing water intake thereby deteriorating litter quality and the environment around birds. Kusina et al. (2001) concluded that without a nutritionally balanced ration, birds will suffer from poor feathering, slow growth, increased fatness and leg problems. Iji et al. (2001) added that...
reducing CP levels and correctly supplying essential amino acids like lysine and threonine have no effect on performance. However, Sonaiya (2011) opposed this arguing that amino acid balance is more important than total CP value if growth is the subject under discussion. In a way or the other, addition of amino acids in commercial diets might have contributed to better growth rates comparing with homemade diets where no farmer was able to supplement them.

Due to the fact that CF for commercial diets was showing lower levels than home-made diets, their digestibilities might have been also higher. Very high CF levels reduces digestibility of feeds as they stay longer in the gizzard and crop thereby reducing feed intake (Madriga et al. 1994). They added that this also causes digestive disorders like necrotic enteritis hence lowering growth rate, causing illness. Moreover, non-ruminants do not have enzymes for digesting cellulose and hence are not efficient utilizers of feeds with high fibre. Sonaiya (2011) argued that increasing dietary fibre above 5% reduces growth rates, nutrient retention and feed intake by increasing fat content through the production of both high density and low density lipoproteins. As shown by the results of the homemade samples analysed, their CF contents were well above 5% and this might have contributed to lower 42 day weights obtained by the farmers using them. Doli et al. (2006) added that sunflower cake that is not dehulled is rather better for ruminants or need to be sieved to remove hulls at a smaller scale to be utilized by broilers. Lilliboe (2005) concluded that the inclusion levels of sunflower meal that is not dehulled should not exceed 5% in starter and 10% in finisher diets. However, no sieving was done on sunflower meals used by farmers and it was observed that for all farmers using it, their inclusion levels were well above 10%.

The mixing procedures and formulas which were used by small holder farmers were not designed by technical people as 60% of people interviewed designed for themselves. There were no standard mixing procedures, no standard formulas and inclusion levels were based on ITK and quantity rather than weights. Moreover, the nutritive values of the ingredients and the final feeds formulated were not known. Oyedeji et al. (2005) added that the quality of feed may be affected by the mixing technique used as energy sources will be more course than protein sources and hence if not properly mixed birds take more of energy than proteins. Though energy intake increases weight by fat accumulation, protein is the most important growth determinant. Novele et al. (2009) and Heuser (2013) agreed that this is the reason why pellets perform better than mashes. As small holder farmers are not capable of pelleting their feeds, they are likely to face the same challenge and hence can lower weights obtained at slaughter.
It was observed that there was no addition of micro packs of vitamins, minerals and amino acids during feed formulation at small scale levels as they were considered to be expensive. They are absolutely critical to all life processes such as growth, maintenance, reproduction (Heuser, 2013). Nir et al. (2009) added that though vitamins do not directly build body tissue as done by macro minerals like calcium and phosphorus, they assist many of the enzymes controlling and metabolic processes of life and are often referred to as co-enzymes. Hence are important for utilisation of feed and growth. Addition of additives like coccidiostat and antibiotics is very rare at small scale but Champion Feed Services (2009) argued that their presence improves health status of the broilers. Conventional feed mills are capable of importing vitamins and amino acids, stimulants and other additives.

Table 4.3 showing mean live weight at day 42 using different feeding phases

<table>
<thead>
<tr>
<th>Feeding regime</th>
<th>Combined Mean weight (kg) at 42 days</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 phase</td>
<td>2.227&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.1520</td>
</tr>
<tr>
<td>3 phase</td>
<td>2.286&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.1375</td>
</tr>
<tr>
<td>4 phase</td>
<td>2.590&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.1418</td>
</tr>
</tbody>
</table>

Mean with different superscript are significantly different (p<0.05)

There was significant difference at 5% significant level on the weight attained at day 42 from farmers using different feeding phases (p<0.05) amongst all breeds. Weights were highest in 4 phases, followed by 3 phases and lastly 2 phases.

Nutritionists have worked on increasing the crude protein and optimizing crude fibre contents of diets as they were moving from 2 to 3 and eventually 4 phases. Extensive researches have been carried out on various combinations of CP and CF, their effects on growth patterns through feeding trials. Insoluble and soluble fibres have been minimised in 4 phase. Soluble fibre reduces passage of feed, reduces digestion of starch, protein and fat, affects viscosity of the digesta and binds to nutrients reducing their availability (Heuser, 2013). Results showed that 4 phase’s diets have the lowest CF and this might have made the diets more utilisable hence yielding better weights. Insoluble fibre improves starch digestibility but accumulates in the gizzard regulating digest passage and is the element that increases dry matter content of
faeces (Eliana and Balcazar, 2010). Luis et al. (2004) concluded that high levels of CF diets is not beneficiary but is required in small quantities for avoiding digestive problems in poultry. Moreover, there is a gradual decrease in CP levels in the later phases like the 4 phase where birds start by consuming a diet with 23%, followed by 21%, 20% and eventually 19%. This gradual decrease is associated with lower stress and has no much impact on the reducing feed consumed as a result of differences in composition. It has also been observed that highly processed and nutritive value ingredients as well as growth stimulants and probiotics have been widely used in the later phases. For example, 33% sunflower is not used on 3 and 4 phase diets but sometimes 40% sunflower can be included in smaller quantities. This is because of its high fibre and imbalance in amino acids. Instead fish meal, meat and bone meal, soya meal and blood meal are commonly used for later phases. Moreover, the differences in weight might have been attributed by the fact that later phase have more CP as proved by the results obtained. This is partly because their targets in terms of CP are different, where taking for example on finisher diets 2 phase target 17%, 3 phase 18% and 4 phase 19% (National foods, 2013). Moreover, amino acids have been balanced by adding enough essential amino acids like lysine and threonine.

Using the Tukey’s HSD, there was no significant mean difference at 5% significant level on the weight attained at day 42 from farmers using 2 and 3 phase (p>0.05) but there the was significant difference on mean weight difference to those using those using 4 phase feeding regimes (p<0.005).

From the results obtained by the tests done, the CP levels were slightly increasing and CF was slightly decreasing from 2, 3 and 4-phase feeding systems though they were a little bit closer on 2 and 3 phase diets. The target percentages of CP are almost similar for 3 and 2 phases and they target the same amount of CF. According to National foods article (2013), 2 phase starter diets targets 20% CP and 3 phase targets 21% CP and both aim below 5% CF. It can be observed that these targets are almost the same though nutritionists are working on increasing amino acid balances in three phase system. World Poultry Net (2009) added that birds using three phase feeding programme should grower better than those using two phase from the period they consume grower diets, which is in the 3rd and 4th week. This is so because the birds following 2 phases will be already consuming finisher diets that are less nutritive than grower diets of 3 phases. Owing to the increased efficiency of protein deposition by three phase grower, it may results in more gain per gram protein deposited than lipid deposited by the 2
phase finisher. Hence, higher rates of protein deposition during the 3rd and 4th weeks would have a significant impact on the overall growth rates (Novele et al., 2009). This makes 3 phases better than 2 phases. This was proved wrong by the results of the survey which showed that there is no significant difference on mean weight difference at 42 days on broilers under 2 and 3 phase systems. However, little differences on weights obtained were noticed. Lee and Lesson (2001) agreed that weights attained at day 42 when using 2 and 3 phase programmes are slightly different and this was supported by results obtained. Hubbard (2013) agreed to that and concluded that fat deposition is higher in 2 phases and hence will add to weight.

As shown by the results in table 4.3, 4-phase is highly nutritious than both 2 and 3 phase diets. Lilburn, (2007) argued that pre-starter diets increase the rate at of development of the proventriculus, gizzard, liver, pancreas, intestine and skeletal development. All these lead to better weights at day 42. Leksrisompong et al. (2006) added that the amount of CP of the diet is not the correct determinant of the nutritive value of a feed but is determined by the amino acid balances. The use of the ideal amino acids like the lysine, iso-leucine, glycine, tryptophan, valine, methionine, threonine, cystine and threonine as done in formulating 4 phase diets have made them special and expensive diets (Ross Poultry Breeders, 2009). Balanced protein level with balanced amino acids in 4 phase helps in maximizing muscle development, full feathering to meet the requirements for optimum performance of meat-type birds (Creswell, 2007). Saki et al. (2010) concluded that 4-phase is the best feed to use for Cobb broilers and it is the phase that have been adopted by Irvine’s in Zimbabwe and they are achieving 1.65kg/28days (Irvine, 2011).

Farmers favouring 2 phase over 3 have mentioned that it is easy and cheap method to use, no complex lighting programs to follow. Those using 3 phase argued that its rationed specific accordingly for different ages, involves a gradual decrease in CP levels hence less stress, relatively fast growth rates and provides uniform growth rates. For those using 4-phases 80% of the farmers interviewed were contract farmers for Irvine’s Zimbabwe hence were given the feed. Despite that, they also mentioned that it is specific for different age groups hence lead to fast growth rate and the prestarter that gives a quick start and produces a good skeletal development.

Table 4.4 showing ranked predictors for adoption from the binary logistic regression
Predictors are shown by odds ratios [Exp (B) > 0] and significant predictors are shown by coefficient (B>0) at 95% confidence interval.

As shown by the table above, sex, age, education, marital status and density were variables that proved to be predictors in adoption of commercial feeds using the Odds ratios [Exp (B) > 0]. Religion showed that it have no relationship in predicting the adoption of commercial diets [Exp (B) = 0]. However, amongst all the independent variables sex, age and education were significant predictors (B>0) whereas status, density and religion were insignificant predictors (B<0) of commercial diet adoption.

The comparison of the costs between farmers using home-made and commercial feeds was not done as the costs of formulating diets on-farm were not available. This was as a result of no documentation of input costs used by farmers.

Sex of the household was ranked the highest predictor of the adoption of commercial feeds over home-made diets [Exp (B) = 3.039]. It implies that a one unit increase of the interviewed farmer being a male increased the odds by 203.9% that the survey respondent adopted commercial feeds. Gender was a significant predictor in commercial diet adoption (B = 1.111) seeing males contributing more. It was observed that males are more interested in commercialization, faster growth rates, responsible for making final decisions hence were opting for commercial diets. Females usually are interested in small scale usually for family consumption and hence try by all means to minimize costs. Moreover, females slaughter their chickens at different intervals and hence no need for uniform and fast growth rates unless
otherwise they will be keeping them for income generating. Therefore, efforts to improve the adoption of commercial feeds should be target male farmers.

The odds ratios ranked age to be the one of the better predictor of adoption of commercial feeds \([\text{Exp} (B) = 1.676]\). Using the same rule, a one unit increase in age increased the odds that farmers would adopt commercial feeds by 67.6%. Age was a significant predictor in commercial diet adoption \((B = 0.517)\) and the age group of 31-40 contributing more. Middle aged people are amongst the working class and are associated with more responsibilities. Due to unemployment, low salaries in the Zimbabwean cities, the working class is forced into small businesses like poultry production for earning a living. This group is still active, energetic and usually prefers commercial diets because they value quick returns. Hence, to improve the adoption of commercial feeds, one should focus on the age group 31-40.

The highest level of education attained was also amongst better predictors of commercial diet adoption in poultry \([\text{Exp} (B) = 1.543]\). The farmers that attained form 4 occupied 45% of the farmers interviewed and have contributed 54.3% for every unit to the change in odds ratios. Level of education is a significant predictor in commercial feed adoption \((B = 0.433)\). The level of education affects the perceptions of farmers and reasoning capacities. Progressive farmers adopt new innovations faster than laggards as they believe in increasing yields. Prokopy et al. (2008) argued that despite level of education, experience can also affect adoption. In improving adoption of commercial feeds, people who have attained form 4 as their highest education level should be targeted.

According to the results obtained marital status was also ranked as a poor predictor of the adoption of commercial diets \([\text{Exp} (B) = 0.287]\). This means that for a single increase of an interviewed farmer being married, it increased the odds of adopting commercial diets by 28.7%. Its coefficient is showing that marital status is not a significant predictor \((B = -1.247)\) in adoption of commercial feeds. Hence married, single, widowed and divorced people are likely to adopt commercial feeds. Though marital status have no much impact on adoption, married people contributed more as they occupied 70% of the interviewed farmers and hence can be targeted when improving adoption of commercial feeds. This is partly because as people marry responsibilities in terms of cash for rentals, school fees for children, food for the family will increase compared to single people.

The location of the farmers interviewed was also amongst the poor predictors of commercial feed adoption \([\text{Exp} (B) = 1.082]\). This was meaning that a single chance that the interviewed
farmer was from high densities, it increased the odds of adopting commercial feeds by 8.2%. Hence the people living either in high or low densities can adopt commercial feeds and hence location was not a significant predictor ($B = -2.287$). Basing on the numbers of interviewed farmers, it can be concluded that concentrating on high densities where more people are into broiler production can be another better way to improve adoption of commercial feeds.

The religion of the farmer was not related in predicting the adoption of commercial diets [Exp $(B) = 0.000$]. This means that all farmers from different religions can adopt commercial feeds and has no effect on predicting adoption of commercial diets ($B = -10.432$). Since statistics shows that more Christians are into broiler production, concentrating on them can however aid in improving adoption of commercial feeds.

**CHAPTER 5**

**5.0 CONCLUSION AND RECOMMENDATIONS**

**5.1 Conclusion**

In this study, there was significant difference on weights at day 42 from farmers using home-made and commercial feeds. Commercial diets have higher CP, lower CF and contributed to better weights than home-made feed. Hence it can be concluded that farmers making their own feeds should concentrate on increasing CP and reducing CF as they are not within the expected ranges of good broiler welfare. Ingredients used in home-made diets should be analyzed, their inclusion levels should be monitored, formulas should be revised, mixing procedures should be improved and essential amino acids, minerals and vitamins should be incorporated into home-made diets.

It was also seen that there was no significant difference on the weight at day 42 between farmers using 2 and 3-phase feeding system and hence choice between the two different feeding phases should be based on the cost and meat quality expected. It was therefore, concluded that both farmers using 2 and 3-phase systems can safely switch and start using 4 phase as it can improve growth rates by a significant margin. In improving adoption of commercial feeds, feed mills can target males, the 31-40 age group, christians, married people, farmers living in high densities and community members that hold form 4 as their highest education qualification as they have proved to be better predictors in adoption of commercial feeds.
5.2 Recommendations

To farmers using their own feeds: need to consider: -

- Send raw materials for nutritive values analysis for coming with feasible inclusion levels as per broiler welfare.
- Use soya bean meal rather than sunflower meal or should screen it through 1mm sieve to reduce fibre.
- Eliminate excess fat from sunflower seeds by physical pressing the seeds.
- Concentrate on increasing their CP and reducing CF in their formulas.
- Send samples of their final product to have an idea of its nutritive value in terms of CP, CF, calcium, fat and other minerals.
- Keep records in order to evaluate whether they are making profits.
- Mix ingredients in small quantities and incorporate vitamin and mineral macro-packs in their formulations.

For farmers using commercial feeds: need to consider: -

- Use 4 phase feeding system preferably to 2 and 3 phase systems.

General recommendations from observations: - should

- Improve ventilation to avoid ammonia build up which is causing odours.
- Insulate chicken houses properly and follow proper lighting programmes to reduce much noise through continued crowing, quacking, clucking and gobbling.
- Turn dry bedding and change wet bedding regularly.
- Proper disposing of bedding in composts or using in vegetable production

For feed manufacturing companies: - should

- Advertise 4 phase feeding programme
- Concentrate more on 2-phase because it is the most commonly used phase
• Target males, 31-41 aged, married, form 4 holders in improving adoption of diets

For further studies

• Other researches should concentrate on the effects of fat content, different housing, different lighting programmes and breeds on weight at day 42 for small holder producers

CHAPTER 6

6.0 REFERENCES AND APPENDICES

6.1 References


Doli M.G., Usturoi M.G., Radu-Rusu, Usturoi A.I. and Luminiţa Doli (2006) *Researches concerning the usage of whole sunflower seeds in poultry feeding*, University of Agricultural Sciences and Veterinary Medicine, Romania.


FAO (2011) *Feed ingredients survey- Feeding poultry, pigs and fish in developing countries*, Poultry, Fisheries and Aquaculture department, Rome, Italy.

Feighner S.D., Dashkevicz M.P. (2010) *Sub-therapeutic levels of antibiotics in poultry feeds and their effects on weight gain, feed efficiency, and bacterial cholytaurine hydrolase activity*, National Centre for Biotechnology Information, USA.


Mapiye C., Mwale M., Mupangwa J. F., Chimonyo M., R. Foti R. and Mutenje M.J.,(2008) A Research Review of Village Chicken Production Constraints and Opportunities in Zimbabwe, Department of Livestock and Pasture Science, Faculty of Science and Agriculture University of Fort Hare, South Africa.


NIRs™ (2013) *Feed and Forage Analyzer*  www.foss.dk accessed on 11/09/14


Ugwu D.S., (1990) *The Economics of Small Ruminant Production by Small Holder Farmers,* University of Nigeria.

Zimbabwe Poultry Association (2012) Zimbabweans giving up steak for chicken, Associated Newspapers of Zimbabwe (Pvt) Ltd.


Irvines (2011) http://www.wattagnet.com/Poultry.aspx accessed on 08/10/14


Profeeds feeding manual (2013) www.progroup.co.zw/profeeds/product/ accessed on 21/08/14

National foods article (2013) www.natfoods.co.zw accessed on 08/12/13


Hubbard Flex Performance (2013) www.hubbardbreeders.com accessed on 3/08/14

6.2 Appendices

APPENDIX 1: Questionnaire on poultry producers in Harare

Questionnaire number: Enumerator’s name ……………

Residential Suburb: Village ……………

Feed depot: Sample number ………………..

Respondent number: Date :

May you please tick or complete the spaces provided:-

1.0 Demographic information

1.1 Sex of head of household: Male □ Female □
1.2 Marital status: Married □ Single □ Widowed □ Divorced □
1.3 What is the age of head of household?
   <20yrs □ 21-30yrs □ 31-40yrs □ 41-50yrs □ >50 yrs □
1.4 Sex of respondent: Male □ Female □
1.5 Highest educational status of the respondent:
   No formal education □ Grade 7 □ Form 4 □ “A” Level □ Diploma □ Degree □
1.6 Race of respondent?
   Black African □ White □ Coloured □ Indian □ Other (Specify)…………………………
1.7 What is your principal occupation? ………………………………………………………
1.8 What is your religion? Christianity □ Muslim □ traditional □ Other (Specify)…………

2.0 Chicken production

2.1 Is the respondent into poultry production? Yes □ No □
2.2 How long has the respondent been into poultry production?
   < 1 year □ 1-2 years □ +2 to 4 years □ More than four years □
2.3 What type of poultry is kept by the respondent
   Broiler □ Layers □ Turkeys □ Guinea fowls □ Ducks □ Other (specify)…
2.4 Rank the preferred type of poultry from 1 (most liked) to 5 (least preferred)
<table>
<thead>
<tr>
<th>Type of chicken</th>
<th>Rank of preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broiler</td>
<td></td>
</tr>
<tr>
<td>Layers</td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td></td>
</tr>
<tr>
<td>Guinea fowls</td>
<td></td>
</tr>
<tr>
<td>Ducks</td>
<td></td>
</tr>
<tr>
<td>Other (specify)</td>
<td></td>
</tr>
</tbody>
</table>

2.5 Does the respondent keep broilers? Yes ☐ No ☐
2.6 Is the respondent the owner of the broiler project? Yes ☐ No ☐
2.7 Which broiler chicken do you keep? Hubbard ☐ Ross ☐ Cobb 500 ☐ Other …………..
2.8 Rank the type of broiler you want to keep from 1 (most liked) to 5 (least preferred)?

<table>
<thead>
<tr>
<th>Broiler type</th>
<th>Rank of choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobb 500</td>
<td></td>
</tr>
<tr>
<td>Hubbard</td>
<td></td>
</tr>
<tr>
<td>Ross</td>
<td></td>
</tr>
<tr>
<td>Other (specify)</td>
<td></td>
</tr>
</tbody>
</table>

2.9 Tick and rank the reason for the above ranking of choice of your broiler

<table>
<thead>
<tr>
<th>Reason</th>
<th>Rank of reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can grow on poor quality feeds</td>
<td></td>
</tr>
<tr>
<td>Easy to manage</td>
<td></td>
</tr>
<tr>
<td>Eats less food</td>
<td></td>
</tr>
<tr>
<td>Fast growth rate</td>
<td></td>
</tr>
<tr>
<td>Low mortality</td>
<td></td>
</tr>
<tr>
<td>Resistant to diseases</td>
<td></td>
</tr>
</tbody>
</table>

2.10 Which breeding system do you use?
All in—all out (one group at a time) ☐ Multiple age (more groups at the same time) ☐

3.0 FEEDING SYSTEMS
3.1 Who supplies you with chicken feed? Tick suppliers and rank them 1 (one that supplies you the most) to 5 (one that you rarely buy from) state reason for ranking

<table>
<thead>
<tr>
<th>Feed supplier</th>
<th>Tick supplier</th>
<th>Rank</th>
<th>Reason for ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Foods</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital Foods</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profeeds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Windmill</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others (specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.2 If you buy commercial feed, who is your favourite supplier? Novatek ☐ Agrifoods ☐ National foods ☐ Profeeds ☐ Capital foods ☐ Windmill ☐ Others (specify)………………
3.3 Do you make your own chicken feeds? Yes ☐ No ☐
3.4 If the answer to 3.3 above is YES, tick the possible reason of making your own feed and rank the reasons in the table below rank 1 (reason that mostly drive you) 5 (least drives you to
mix your own feeds)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Tick (√)</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Because I grow own ingredients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I buy own ingredients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I get donations of ingredients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I grew up in a family that mixed own feeds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I had formal training on feed formulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (Specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.5 Did you ever receive formal training on feed formulation? Yes ☐ No ☐

3.6 If you received training on feed formulation, who trained you? ...........................................

3.7 List the ingredients that you use to formulate your own chicken feed .................................

3.8 If the ingredients written in 3.7 are not available what do you use to substitute them?
(a) .................................. substitute with ............

3.9. Is there any treatment that you do to the feed ingredients before using them?

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Treatment done to ingredient</th>
<th>Reason for the treatment before mixing</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a).........</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.10 Is there a written mixing procedure that you follow when mixing own feed? Yes No ☐

3.11 Who designed the mixing procedure for you? ...............................................................

3.12 Have you ever heard about micro ingredients? Yes No ☐

3.13 What do you think micro ingredients are? .................................................................

3.14 What do you think is the reason for using micro ingredients? ..............................

3.15 State examples of micro ingredients.

3.16. Kindly give the enumerator a small sample (e.g. 200g) of feed that you prepared for a recent batch of chicken and put label on:
(a) Date prepared ..........................................
(b) Type of chicken fed ...................................
(c) How it was mixed ................................................
(d) Duration of feed e.g. from ...... days old to ........... days old

3.17 For the batch that ate the home mixed feed state the following:
(a) Mortality % at six weeks ..........................................
(b) Weight at six weeks ...............................................
(c) Number of birds at six weeks .................................
(c) Duration of time taken to sale the chickens ...................

3.18 Are you happy with the performance of your chickens on the feed that you produce
Yes ☐ No ☐

3.19 If you are not happy what are the challenges that you can complain about? .................

**4.0 Flock Health**

4.1 Do you vaccinate your chickens? Yes No ☐

4.2 If the answer is yes, which vaccines do you use and at what age?

<table>
<thead>
<tr>
<th>Vaccine used</th>
<th>Date vaccinated</th>
</tr>
</thead>
</table>
4.3 When chickens fall sick, state the action taken and rank the action. Rank 1 (action mostly done) 5 (action least taken)

<table>
<thead>
<tr>
<th>Action</th>
<th>Tick (✓)</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buy medication and treat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Call a veterinary doctor for advice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eat the chicken</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ignore</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kill the chicken and sell</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Look for traditional medicine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.4 If you use any traditional medicines, which ones do you use and for which problems?

<table>
<thead>
<tr>
<th>Traditional medicine</th>
<th>Problem used to treat</th>
</tr>
</thead>
</table>

4.5 Did you experience any feed related problems/diseases? Yes ☐ No ☐

4.6 What is the name of that disease/condition…………………………………………………………

4.7 Can you name any other diseases that you have experienced……………………………………

4.8 What do you think was the cause of the diseases? ………………………………………………………

4.9 Do you add any antibiotic in feeds or water that you give your birds? Yes ☐ No ☐

4.10 What is the name of the antibiotics that you use? …………………………………………………

4.11 Do you follow a defined vaccination programme? Yes ☐ No ☐

4.12 Can you describe how you vaccinate your birds……………………………………………………

4.13 Where do you dispose your bedding………………………………………………………………………

4.14 Where do you store your feeds? ……………………………………………………………………………

4.15 What do you do with the residual feed when giving fresh feed? ………………………………………

4.16 Do your chickens show any of the following signs and symptoms? Rank the occurrence of the problems.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Tick (✓) if they experience problem</th>
<th>Rank occurrence of problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicken skin turning green</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water in the abdomen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pale combs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stunted growth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of feathers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cannibalism</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.1.7 When such problems occur how do you address the problem? Write problem and solution…………………………………………………………………………………………
### APPENDIX 2: Table showing effects of feed source and CP, CF content on weight at day 42

#### Tests of Between-Subjects Effects

**Dependent Variable: Weight at day 42**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>1.936a</td>
<td>14</td>
<td>.138</td>
<td>9.039</td>
<td>.000</td>
</tr>
<tr>
<td>Intercept</td>
<td>144.524</td>
<td>1</td>
<td>144.524</td>
<td>9448.268</td>
<td>.000</td>
</tr>
<tr>
<td>Block</td>
<td>10.754</td>
<td>2</td>
<td>1.876</td>
<td>14.345</td>
<td>.743</td>
</tr>
<tr>
<td>Feedsource</td>
<td>1.400</td>
<td>6</td>
<td>.200</td>
<td>13.073</td>
<td>.000</td>
</tr>
<tr>
<td>Nutritivevalue</td>
<td>1.376</td>
<td>1</td>
<td>.055</td>
<td>8.086</td>
<td>.000</td>
</tr>
<tr>
<td>Feedsource * Nutritivevalue</td>
<td>1.078</td>
<td>8</td>
<td>.038</td>
<td>6.565</td>
<td>.000</td>
</tr>
<tr>
<td>Error</td>
<td>.688</td>
<td>45</td>
<td>.015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>184.280</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>2.624</td>
<td>59</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. R Squared = .738 (Adjusted R Squared = .656)

### APPENDIX 3: Table showing effects of feed sources and analysis method on the CP and CF content of the feed

#### Tests of Between-Subjects Effects

**Dependent Variable: Crude protein and Crude fibre content**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>30.903a</td>
<td>12</td>
<td>2.575</td>
<td>9.364</td>
<td>.000</td>
</tr>
<tr>
<td>Intercept</td>
<td>169.185</td>
<td>1</td>
<td>169.185</td>
<td>615.171</td>
<td>.000</td>
</tr>
<tr>
<td>Feedsource</td>
<td>17.047</td>
<td>6</td>
<td>1.841</td>
<td>10.331</td>
<td>.000</td>
</tr>
<tr>
<td>Analysismethod</td>
<td>6.042</td>
<td>1</td>
<td>.042</td>
<td>.154</td>
<td>.697</td>
</tr>
<tr>
<td>Feedsource * Analysismethod</td>
<td>18.650</td>
<td>8</td>
<td>1.065</td>
<td>12.876</td>
<td>.645</td>
</tr>
<tr>
<td>Error</td>
<td>8.526</td>
<td>31</td>
<td>.275</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>235.490</td>
<td>44</td>
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<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>39.428</td>
<td>43</td>
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</tr>
</tbody>
</table>

a. R Squared = .784 (Adjusted R Squared = .700)
APPENDIX 4: Table showing effects of phases on weight at day 42

Tests of Between-Subjects Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>2.427(^a)</td>
<td>2</td>
<td>1.213</td>
<td>19.111</td>
<td>.000</td>
</tr>
<tr>
<td>Intercept</td>
<td>101.564</td>
<td>1</td>
<td>101.564</td>
<td>1599.625</td>
<td>.000</td>
</tr>
<tr>
<td>Block</td>
<td>8.634</td>
<td>2</td>
<td>1.765</td>
<td>13.065</td>
<td>.865</td>
</tr>
<tr>
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<td>1.213</td>
<td>19.111</td>
<td>.000</td>
</tr>
<tr>
<td>Error</td>
<td>2.349</td>
<td>37</td>
<td>.063</td>
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<td></td>
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<tr>
<td>Total</td>
<td>140.200</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>4.776</td>
<td>39</td>
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</tr>
</tbody>
</table>

a. R Squared = .508 (Adjusted R Squared = .482)

APPENDIX 5: Table showing the significances of mean differences between phases

Multiple Comparisons

<table>
<thead>
<tr>
<th>(I) feeding phase used</th>
<th>(J) feeding phase used</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tukey HSD</td>
<td>2 phase</td>
<td>3 phase</td>
<td>-.054</td>
<td>.0852</td>
<td>.801</td>
<td>-.262</td>
<td>.154</td>
</tr>
<tr>
<td></td>
<td>4 phase</td>
<td>3 phase</td>
<td>-.054</td>
<td>.0852</td>
<td>.801</td>
<td>-.262</td>
<td>.154</td>
</tr>
<tr>
<td></td>
<td>4 phase</td>
<td>3 phase</td>
<td>-.054</td>
<td>.0852</td>
<td>.801</td>
<td>-.262</td>
<td>.154</td>
</tr>
<tr>
<td></td>
<td>3 phase</td>
<td>2 phase</td>
<td>.054</td>
<td>.0852</td>
<td>.801</td>
<td>-.154</td>
<td>.262</td>
</tr>
<tr>
<td></td>
<td>4 phase</td>
<td>2 phase</td>
<td>.054</td>
<td>.0852</td>
<td>.801</td>
<td>-.154</td>
<td>.262</td>
</tr>
<tr>
<td></td>
<td>3 phase</td>
<td>2 phase</td>
<td>.054</td>
<td>.0852</td>
<td>.801</td>
<td>-.154</td>
<td>.262</td>
</tr>
<tr>
<td></td>
<td>4 phase</td>
<td>3 phase</td>
<td>.054</td>
<td>.0852</td>
<td>.801</td>
<td>-.154</td>
<td>.262</td>
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<td>3 phase</td>
<td>4 phase</td>
<td>.054</td>
<td>.0852</td>
<td>.801</td>
<td>-.154</td>
<td>.262</td>
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<tr>
<td></td>
<td>3 phase</td>
<td>4 phase</td>
<td>.054</td>
<td>.0852</td>
<td>.801</td>
<td>-.154</td>
<td>.262</td>
</tr>
<tr>
<td></td>
<td>4 phase</td>
<td>4 phase</td>
<td>.054</td>
<td>.0852</td>
<td>.801</td>
<td>-.154</td>
<td>.262</td>
</tr>
</tbody>
</table>

Based on observed means.

The error term is Mean Square (Error) = .063.

\*: The mean difference is significant at the .05 level.
APPENDIX 6: Table showing the predictor variables of adoption

<table>
<thead>
<tr>
<th>Variables in the Equation</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>-2.287</td>
<td>1.360</td>
<td>4.828</td>
<td>1</td>
<td>.013</td>
<td>1.082</td>
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<tr>
<td>Sex</td>
<td>1.111</td>
<td>1.091</td>
<td>21.037</td>
<td>1</td>
<td>.000</td>
<td>3.039</td>
</tr>
<tr>
<td>Status</td>
<td>-1.247</td>
<td>.731</td>
<td>12.913</td>
<td>1</td>
<td>.008</td>
<td>.287</td>
</tr>
<tr>
<td>Age</td>
<td>.517</td>
<td>.567</td>
<td>30.830</td>
<td>1</td>
<td>.000</td>
<td>1.676</td>
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<td>Education</td>
<td>.433</td>
<td>.324</td>
<td>3.790</td>
<td>1</td>
<td>.003</td>
<td>1.543</td>
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<td>-10.432</td>
<td>9.577</td>
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<td>.999</td>
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<td>1.088</td>
<td>14.040</td>
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<td>.080</td>
</tr>
</tbody>
</table>

<sup>a</sup> Variable(s) entered on step 1: density, Sex, Status, Age, Education, and Religion.