THE EFFECTS OF SUBSTITUTING COTTON SEED CAKE WITH DRIED POULTRY LITTER IN THE PEN FATTENING OF BEEF CATTLE

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A thesis submitted in partial fulfilment of the requirements for the degree of BSc (Hons) Livestock and Wildlife Management, Faculty of Natural Resources Management and Agriculture, Midlands State University

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Declaration of thesis

I hereby declare that this thesis is composed of work carried out by myself unless otherwise acknowledged and that this thesis is of my own composition. The research was carried out during the period of November 2013 to February 2014. This thesis has not in whole or in part been previously submitted for any other degree or professional qualification.

Victor Mhaka

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Date

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Certification of thesis work

I the undersigned, certify that Victor Mhaka, a candidate for the degree of Bachelor of Science (Honours) in Livestock and Wildlife Management in the Faculty of Natural Resources Management and Agriculture has presented this thesis with title:

The effects of substituting cotton seed cake with dried poultry litter in the pen fattening of beef cattle

That this thesis is accepted in form and content and that a satisfactory knowledge of the field covered by the thesis was demonstrated by the candidate through an oral examination held on the 12th day of May 2014.

Supervisor

Mr L. Masaka

Signature…………………

Dedication

Especially dedicated to my late father Ernest and Essie my mother whose parenthood I rate as five star.

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This research was made a success through direct and indirect contributions of a number of individuals. For those who directly contributed towards the success of the work it would be fair to name them all but they are too many.

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My partnership with all these people exists in as far as the quality of the dissertation is good, but the partnership terminates when it comes to the poor aspects of the dissertation. I am solely and fully responsible for all inaccuracies and flaws.

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Abstract

Exorbitant prices and the unavailability of cotton seed cake on the Zimbabwean market are a major constraint to pen fattening of beef cattle on the farms. This study was conducted at New Donnington Farm to evaluate the effects of dried poultry litter (26% Crude Protein) as a substitute of cotton seed cake (31% Crude Protein) on average daily gain, total weight gain, feed conversion ratio and costs of formulating rations of Brangus steers. Thirty steers aged 18 months weighing 300±5 kg were randomly allocated to 5 treatments, 24 steers were fed dried poultry litter based rations and 6 steers were fed the control ration for 90 days in a completely randomised design experiment which was replicated six times. Formulated rations were Isoenergetic (12.50 MJ ME/ kg) and Isonitrogenous (16% Crude Protein). The final average daily gains, total weight gains and feed conversion ratios were significantly different ($p>0.05$) for all treatments. Treatment 1 (control) had the highest average daily gain, total weight gain and least feed conversion ratio followed by treatment 2 (25% dried poultry litter). Treatment 5 (100% dried poultry litter) had the least average daily gain, total weight gain and highest feed conversion ratio. Average daily gain and total weight gain declined as dried poultry litter inclusion levels increased whilst the feed conversion ratio increased with an increase in level of dried poultry litter inclusion. Dried poultry litter inclusion reduced fattening costs without adverse effects on steers' performance at low inclusion levels. Based on the findings of this study dried poultry litter is a fairly low quality feed that reduces production at higher inclusion levels in fattening diets.

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List of Abbreviations

ADG	Average daily gain
CRD	Completely randomised design
CSC	Cotton seed cake
CV	Coefficient of variation
DA	Diode Array Analyzer
DPL	Dried poultry litter
FCR	Feed Conversion ratio
LSD	Least significant difference
MCP	Monocalcium phosphate
NIR	Near Infra-red Reflectance Spectroscopy
NPN	Non protein nitrogen
SEM	Standard Error of Means
TWG	Total weight gain
USA	United States of America
US$	American dollar
p	Probability
Kg	Kilogramme
mm	Millimetre
%	Percentage
^{0}C	Degrees Celsius

CHAPTER ONE

INTRODUCTION

1.0 Introduction

The high costs and to some extent unavailability of plant protein sources especially cotton seed cake in stock feed manufacturing and ration formulation on the farms has made research interest to be focused on coming up with alternatively cheaper protein sources (Chisoko, 2004; Ngongoni, Mapiye, Mwale, Mupeta and Chimonyo, 2007). The least cost ration can be formulated by reducing the level of inclusion of cotton seed cake (CSC) and alternatively substituting with dried poultry litter (DPL).

Adams, Baily, Hoskins and Oliver (2005) reported that cotton has become the symbol of injustice in international trade relations due to low prices on the world market. Consequently, beef producers have been greatly affected because the costs of pen fattening have gone up. The main goal of a beef enterprise just like any other business is to maximise profit which is not a true reflection under the prevailing circumstances. In agriculture the cash invested is termed 'the fuel' which is injected into operations and utilised to generate more cash hence the need to investigate the effects of cheaper alternative protein source ingredients in ration formulation so that the beef enterprise remains viable and feasible.

1.1 Background information

Animal feeds are classified into six groups of which DPL belongs to the group of animal by-products whilst CSC is a member of oil-seeds and grain legumes (Topps and Oliver, 1993). DPL is mainly used as a soil conditioner which is applied on farm land to improve crop and vegetable production. During the dry season DPL is used as a winter supplement for cows and weaned calves on the farms. The use of DPL clearly indicates that there are some nutrients available hence the need to use it more valuably by incorporating it in fattening rations. The use of DPL as an animal feed is also supported by Hadjipanayiotou, Labban, Kronfoleh, Verhaeghe, Naigm, AI-Wadi and Amin (1993) who reported that the inclusion of DPL in ruminant diets has a value which is 3-10 times greater than its value as a plant fertiliser.

There are wide variations in the nutritional composition of DPL hence the need to come up with specific levels of inclusion in ration formulation for specific areas (Mavimbela, 2000). The inclusion levels ascertained in other countries may be used here in Zimbabwe but composition of any plant species, and so its nutritional value, may vary considerably with the country of production (Topps and Oliver, 1993). The differences are due to climate, soil types, agronomic practices, plant varieties grown and the methods of conservation implemented in different countries. It is against this background that the researcher found it valuable to share with beef cattle producers the benefits derived from substituting cotton seed cake with dried poultry litter in the pen fattening of beef cattle.

1.2 Problem statement

High prices and sometimes the unavailability of plant protein rich concentrates have made research interests to investigate the effects of alternative cheaper protein sources like DPL without compromising animal performance.

1.3 Justification

Currently on the Zimbabwean market a tonne of CSC costs US $350 whilst a tonne of DPL costs US $60 (Chabikwa 2013). Research by other animal nutritionists revealed that DPL contains large amounts of protein and fibre. Apart from supplying protein and fibre, DPL also supplies energy, fat, calcium, phosphorus, magnesium, selenium, sulphur and zinc all of which are required by animals in different proportions. From the Crude Protein (CP) available in DPL one third is present as true protein whilst the other two thirds are available as Non Protein Nitrogen (NPN) in the form of uric acid which can be utilised by ruminants like cattle (Ghaly and McDonald, 2012). Snow and Ghaly (2007) found that from the protein available in DPL, 55-60% is digestible by ruminants.

Poultry production is one of the fastest growing sectors of livestock production in the world with an average annual growth rate of 35% (Ghaly and McDonald, 2012). Zimbabwean poultry industry also has experienced a significant growth during the period 2009-2012 as a result of increased production by commercial producers and small to medium producers. Broiler production has grown by more than 500% whilst egg production rose by 300% annually (Chihora, 2013). With such a growth rate from the poultry industry it clearly indicates that DPL supply will be consistent. Each broiler on average produces 1.5 kg poultry excreta over a period of 6 weeks whilst a layer type bird produces on average 16.7 kg poultry excreta annually (Gova, Chimowa and Zawe, 2011). Considering the low prices, the availability in large quantities and the nutritional value, DPL can be a good substitute for CSC.

1.4 Broad objectives

The broad objectives of the research are:

- To determine the response of fattening beef steers fed rations containing DPL as a substitute of CSC at varying levels.

1.5 Specific objectives

The specific objectives of the research are:

- To determine whether substitution of CSC with DPL results in weight gains similar to those obtained with CSC as the main protein source.
- To determine the optimal inclusion rate of DPL in fattening beef cattle diets.
- To determine the economic benefits derived from the substitution of CSC with DPL in fattening beef cattle rations

1.6 Hypotheses

H_0: DPL does not result in total weight gains similar to CSC.

H_0: DPL does not result in average daily weight gains similar to CSC.

H_0: DPL does not result in feed conversion ratio similar to CSC.

H_0: DPL inclusion in the diets does not reduce the costs of feeds.

CHAPTER TWO

LITERATURE REVIEW

2.0 DPL as a feed ingredient of animal diets

DPL either on its own or when mixed with other feed ingredients like feed grains, proved to be a valuable feed for ruminant animals, fish and even monogastric animals like pigs (Snow and Ghaly, 2007; Adesehinwa, Obi, Makanjuola, Adebayo and Durotoye, 2010; Bolan, Szogi, Chuasavathi, Seshadri, Rothrock and Panneerselvam, 2010; Sharpley, Slaton, Tabler, Van Devender, Daniels, Jones and Daniel, 2012). Research on feeding DPL to animals especially ruminants has been conducted since 1950 (Fontenot and Hancock, 2001). World over DPL has attracted the attention of so many animal nutritionists as a potential protein source (Obasa, Alegbeleye and Amole, 2009). Ngongoni and Manyuchi (1993) reported that worldwide research has been conducted on the use of DPL as an animal feed and researches continued in Africa in the 1990s. Bolan *et al*. (2010) reported that DPL has a value that is more than 4 times higher as an animal feed than its use as a soil conditioner.
Animals in Zimbabwe suffered severe nutritional stresses due to high prices and unavailability of protein rich commercial concentrates and this justified the need to investigate alternative sources of protein (Ngongoni *et al.*, 2007). Matenga, Ngongoni, Titterton, and Maasdorp (2003) reported insufficient protein as one of the greatest constraints to ruminant animal production in Zimbabwe. Matenga *et al*. (2003) suggested the nutritive evaluation of alternative protein sources as a necessary area of research because the conventional protein supplements like fish meal, blood meal, CSC, soya bean meal and sunflower meal were reported to be unavailable or too expensive in Zimbabwe. Ngongoni and Manyuchi (1993) found that DPL is a good source of cheap protein for animal production.

Due to increased costs of plant protein sources like soya bean meal, CSC, ground nut meal and sunflower meal animal nutritionists investigated the use of DPL as a potential substitute of the costliest plant protein ingredients (Lanyasunya, Rong, Abdulrazak, Kaburu, Makosi, Onyango and Mwangi, 2006; Adegbola, Smith and Okeudo, 2009). Van Ryssen and Van Malsen (1993) also reported high costs of protein sources and the risk of shortages of such protein sources in South Africa. Globally the increased costs of plant protein sources raised the production costs in the livestock industry especially beef production, dairy production, sheep and goat production, pig production and even fish production (Obasa *et al.*, 2009).

Gadberry (2000) reported that due to the unique digestive system possessed by ruminant animals, they could utilise by-products as sources of dietary nutrients. Ruminant animals were reported to utilise the nitrogen components in DPL to synthesise protein. Beef, dairy, sheep and goats industries have been built largely using by-products that can be digested only by ruminants. Gadberry (2000) and Rankins (2000) also revealed that DPL is a potential source of protein and minerals which should be used as a feed ingredient provided that it is of good quality and suitable for feeding animals.

Belewu (1997) found that the utilisation of DPL in the livestock industry provided a profitable means of litter disposal and at the same time livestock producers especially cattle, dairy, sheep and goats were afforded an attractive inexpensive feed with a value equivalent to grains. The uric acid present in DPL was best utilised by ruminants to synthesise microbial protein. Uric acid formed two thirds of protein as a NPN and the remaining one third is true protein. Moderate protein and energy diets used to supplement poor roughage diets during the hot and dry season were formulated with DPL as the main protein source and such diets proved to be of great value when it comes to animal performance.

According to Adegbola *et al*. (2009) the utilisation of DPL was comparable to plant protein feedstuffs in Nigeria. The production costs of formulating the dietary rations were reduced by 20-40%. Snow and Ghaly (2007) outlined the advantages of incorporating DPL in cattle feeds and some of the advantages include the following:

- Inclusion of DPL in ration formulation reduced production costs of beef cattle without adverse effects on animal performance.
- The use of DPL as an animal feed proved to be an environmentally responsible use of a by-product and this provided an incentive for the proper management of the by-product by poultry and cattle producers alike.

Chabikwa (2013) reported that cotton formerly known as the ‘white gold’ in Zimbabwe is under threat. The world market prices have gone down. In Zimbabwe the first grade cotton’s gazetted prices for 2012-2013 farming season were US $0.38 per kilogramme for the first grade cotton and US $0.28 for the least grade against a minimum of US$1.31 demanded by cotton producers (Chabikwa, 2013). As a result of this scenario the prices of the by-product (CSC) went up and remained in short supply locally. The local suppliers of CSC were left with no options other than importing the scarce by-product. In 2013 the local suppliers were selling a tonne of CSC at around US$ 300 (Chabikwa, 2013). High prices of plant protein sources experienced in other countries like South Africa, Nigeria, Syrian Arab Republic and Mauritius forced animal nutritionists to investigate the best inclusion levels of alternative protein sources like DPL (Chisoko, 2004; Adegbola *et al.*, 2009 and Obasa *et al.*, 2009). Ruminant animals in Nigeria were underfed due to high costs of feed ingredients especially plant proteins like soya bean meal, CSC and ground nut meal and the use of DPL as a substitute of such plant protein sources reduced the costs and improved animal performance (Belewu, 1997).

2.1 Variations in nutritional value of DPL

McDonald, Edwards, Greenhalgh, Morgan, Sinclair and Wilkinson (2010) found that DPL vary considerably in composition depending upon their origins. According to Ghaly and McDonald (2012) there is still a lot of research to be done on DPL as a feed resource for ruminant due to variations in nutritional composition. Animal nutritionists from different parts of the world worked on DPL as a substitute of plant protein sources and carried out feeding trials after analysing the nutritional value of the ration ingredients including DPL.
The importance of nutritional composition analyses and feeding trials before ascertaining optimal levels of DPL inclusion in feeding diets was strongly recommended by Mavimbela (2000); Gadberry (2000) and Van Ryssen (2001). The nutritional values of DPL ascertained in other countries should not be used in different places because of reported nutritional values' variation. Causes of variations in nutritional composition were reported to be varying agricultural practices, processing and conservation methods (Topps and Oliver, 1993; Cross, 1995; Belewu, 1997; Mavimbela, Van Ryssen and Last 1997). According to Gadberry (2000) there are no set standards of bedding material used in deep litter system of broiler production and consequently litter qualities vary from one poultry farm to another.

According to Ghaly and McDonald (2012) DPL supplied dietary fibre and one third was derived from the excreta itself whilst two thirds came from the bedding material used in poultry houses. It was found that the chemical composition and the physical properties of the bedding material affected the nutritional value of DPL. Age advancement of broilers resulted in an increase in dry matter, crude protein and crude fibre content. Ether extract was not stable and fluctuated throughout the rearing period. Decline in CP content was observed in DPL stored for a period exceeding one month as a result of ammonia losses.

As a result of variations in nutritional composition of DPL the desired animal performance can only be obtained through adjustment of DPL to grain ratio in the ration formulated

(Bolan *et al*, 2010). Maize was recommended as the high energy source and also for enough fermentable carbohydrates in the rumen. DPL intended for inclusion in dietary rations should be analysed first for nutrient profiles to determine if it is worth feeding to animals or not. For pen fattening rations the DPL CP should be in the range of 18-28% on dry matter basis if DPL is to be used as the sole protein source (Snow and Ghaly, 2007; Adesehinwa *et al.*, 2010). Proper balancing of rations proved to be of vital importance since it maximised efficiency and economic returns (Cross, 1995).

Evers, Greene, Carey and Doctorian (1996) found that DPL inclusion at more than 50% of the total ration resulted in over feeding protein and minerals. Under such circumstances copper toxicity was documented in sheep because copper was reported to be 5 times greater than the recommended maximum level. Low energy levels were however reported at inclusion levels greater than 50% (Evers *et al*., 1996). Also very low levels of fat soluble Vitamins A and E essential for normal growth and reproduction of animals were reported.

In a study carried out by Van Ryssen and Van Malsen (1993) a total of 259 representative samples from poultry enterprises around South Africa were collected for analysis in the laboratory. Stock feeds for all the enterprises were supplied by 12 different South African suppliers in and the bedding material was mainly wood shavings. Analyses showed a lot of variations from DPL crude protein, crude fibre, moisture, ash and minerals. Some of the noted differences were based on production systems for example mineral concentrations were reported substantially lower in broiler and pullet samples compared to layer and breeder samples. Most of the samples met the phosphorus, magnesium and potassium requirements of beef cattle and sheep (1.6-3.8/kg) (Van Ryssen and Van Malsen, 1993).

Zinn, Barajas, Montano and Shen (1996) found that both nutritional composition and feeding values of DPL differed markedly from the published values. In a study carried out by Zinn *et al.* (1996) DPL supplied 5.68 MJ ME/ kg DM. The energy value was however 41% less than the published value in the tables of feeding standards by National Research Council (NRC) (1984). Van Ryssen (2001) analysed DPL for energy and found an average of 9.0 MJ ME/kg DM.

2.2 Nutritional composition of DPL

Different nutritional compositions of DPL from six different published articles from different parts of the world compared to the daily beef cattle requirements set by National Research Council (NRC) (1984) are illustrated in **Table 1**.

Table 1: Different nutritional values of DPL compared to the set values by NRC (1984)

Item	a	b	c	d	e	f
Energy MJ ME/ kg	34	15.3	8	7.4	10	181
Crude Fibre %	14	21	18	24	15	6.5
Crude Fat %	7.3	5.5			1.5	6.3
Crude Protein %	7.6	28	22	23	24	42
Macronutrients %						
Calcium	1.8	2.6	2.15	2.9	2.5	0.04
Magnesium	1	0.5	0.6	0.7	0.6	0.02
Phosphorus	0.8	2.3	1.8	1.6	1.5	0.01
Potassium	6.5	2.2	2.6	2.7	1.3	0.11
Sodium	0.8	0.6	1		0.6	0.04

a- NRC (1984) Beef cattle daily nutrients requirements

b- Robinson and Beauchamp (1991)

c- Evers *et al.* (1996)

d- Gadberry (2000)

e- Van Ryssen (2001)

f- Ghaly and McDonald (2012)

Van Ryssen (2001) found that the wide variations in the chemical composition of DPL complicated ration formulation with the ingredient in different parts of the world. USA DPL yielded 181 MJ ME/ kg energy from an analysis carried out by Ghaly and McDonald (2012) on dry matter (DM) basis whilst DPL from South Africa yielded 10 MJ ME/ kg energy from an analysis carried out Van Ryssen (2001). According to Belewu (1997) literature on DPL showed wide variations in chemical composition between individual countries and the following are reported causes of variation:

- Composition of the diet of birds (broilers or layers' feed)
- Type of bedding material used (saw dust, bagasse, straw, hay, hulls)
- Litter processing and management
- Number of birds and duration of birds on bedding material

Van Ryssen (2001) found that South African DPL contained more fibre than USA DPL. In USA 5-6 batches of broilers are kept on the same litter material before the poultry houses are cleaned whilst in South Africa the poultry houses are cleaned after every batch of broilers (Mavimbela, 2000). The differences were caused by higher proportions of bedding material in South African DPL and higher ammonia losses during sun drying than in USA DPL. South African DPL had a larger proportion of soils than USA DPL and this resulted in much lower concentrations of macro and micronutrients in USA DPL compared to South African DPL (Van Ryssen, 2001, Mavimbela, 2000; Bolan *et al.*, 2010).

DPL had deficiencies in fat soluble vitamins A and E (Evers *et al.*, 1996; Gadberry, 2000; Mavimbela, 2000; Van Ryssen, 2001). Van Ryssen (2001) reported that copper levels ranged within the acceptable intake levels for sheep because copper sulphate that is used in USA broiler diets is not used in Republic South Africa broiler diets.

2.3 Animal health status

Gadberry (2000) and Rankins (2000) reported that DPL has been used as a feed ingredient for more than 40 years without harmful effects to people who have consumed such animals or animal products. Disease problems have not been reported (Fontenot and Hancock, 2001). From a hygiene stand point, unprocessed dietary litter contained potential pathogenic microorganisms like *Salmonella*, *Enterobacter* and *Clostridium species* (Ghaly and McDonald, 2012). All litter regardless of its source should be processed to eliminate pathogenic microorganisms. Feed additives like antibiotics and coccidiostats could be found in poultry excreta. To reduce the risks from drug residues in the tissues of animals that are fed rations with DPL all litter feeding should be discontinued 15days before the animals are marketed for slaughter (Snow and Ghaly, 2007).

According to Evers *et al.* (1996) there is need to thoroughly check for wires, nails and broken bottles in DPL before rations are formulated and fed to animals. Milk fever was completely eradicated from properly balanced DPL rations in which all the known deficiencies were supplemented. Milk fever is associated with calcium or magnesium deficiency or an imbalance with other minerals in the ration. For sheep and lactating dairy and beef cattle 20% level of inclusion of DPL proved to have no adverse effects (Gadberry, 2000).

Mavimbela *et al.* (1997) reported on the need to vaccinate animals against botulism and also the need to deworm against helminths. No cases of the disease botulism caused by *Clostridium botulinum* were reported from vaccinated animals fed sun DPL based rations. All the recorded botulism cases were caused by the presence of poultry carcasses in the DPL. The poultry carcasses harbour the preformed toxins which when ingested by cattle proliferate resulting in hind limb paralysis and finally the forelimbs. The best method suggested to prevent the disease included good management practices like the exclusion of dead birds and other extraneous material of the litter prior to ration formulation and feeding.

2.4 Processing methods of DPL

Processing of DPL enhanced feed intake, controlled odour and contributed to both animal and human health (Bernhart and Fasina, 2009). According to Belewu (1997) DPL can be processed using any of the following methods:

- Mechanical method
- Biological method
- Chemical method

2.4.1 Mechanical method

Mechanical method is the mechanical drying of the poultry litter to reduce the bulkiness by 70-80% of the original volume (Fontenot, 1996; Belewu, 1997; Snow and Ghaly, 2007). Ghaly and McDonald (2012) outlined the process of drying as the removal of moisture from the poultry litter so that it is near equilibrium with the atmospheric air. Litter stickiness was eradicated completely and easy handling was enhanced in the trials carried out. Rate of deterioration due to chemical and biological activity was also minimised.

Drying can be carried out using a variety of heat sources like solar energy, electricity, natural gas or other fossil fuels. The sun drying method was recommended over other methods because other methods are associated with high cooking and drying energy costs and also high costs of equipment for cooking and drying for example autoclaves (Bernhart and Fasina, 2009). Sun drying method was recommended because the sun is available in abundance throughout the year especially in the tropics and the method proved to be effective in most of the experimental trials carried out in different parts of the world (Obasa *et al.*, 2009). Higher oxidation rate, odour control, pathogen destruction and good waste stabilization were all reported from sun DPL (Belewu, 1997). Sun drying proved to be an economic method of processing poultry manure compared to other mechanical methods like heat air drying where the use of expensive electric driers is required.

Onider, Siebenmorgen and Mauromoustakos (2010) found good results by sun drying poultry litter at 26^0C with a relative humidity range of 19-68%. For fast drying thin layers of about 1cm proved to be effective and the moisture content was recommended to be left at around 12-13%. DPL with moisture content below 12% had low CP due to nitrogen losses and when such DPL was incorporated in feeding rations, dust that reduced feed intake was reported (Fontenot, 1991). Cases of Mycotoxins that are produced by Aspergillus were observed from DPL with moisture content above 13% (Van Ryssen, 2001).

2.4.2 Biological method

The biological methods involve the use of living organisms for example insect culture (Belewu, 1997). In a study carried out by Belewu (1997) larvae of dipteral species transformed 80% of organic matter of DPL and reduced moisture content from 75% to 50%. Poultry litter can also be ensiled alone or with any soluble carbohydrate so as to enhance the quality of the fermentation process. Deep stacking method was found to be effective in eliminating pathogens present in the poultry litter (Ghaly and McDonald, 2012)

2.4.3 Chemical method

In this method poultry litter is collected and is then chemically treated with substances such as purple iodine and ethylene oxide which do not affect the chemical composition of DPL (Belewu, 1997). Immediate harvesting and low energy and labour requirements are the reported advantages. The main disadvantages associated with the chemical method include the expensive mixing equipment and the costly chemicals. Martens and Bohm (2009) found that ethylene oxide is commonly used in the chemical treatment of DPL in developed countries like USA.

2.5 Feed intake by animals fed DPL

Evers *et al.*, (1996) revealed the importance of gradually introducing rations with DPL to animals at whatever inclusion level. Maximum feed intake in most of the feeding trials carried out was observed after two weeks when the animals were accustomed to the formulated rations. Mavimbela, Van Ryssen and Last (1997) found that molasses inclusion in rations containing DPL as the major protein source enhanced feed intake by animals. Molasses addition enhanced feed palatability which in turn resulted in significant increased voluntary feed intake and finally average daily gain in live mass. Sheep fed 15% molasses diet with DPL as the main protein source reached optimum intake of feed after three weeks compared to the sheep on 7.5% molasses ration that reached optimum intake at 6-7 weeks.
Nadeem, Ali, Azim and Khan (1992) reported a linear depression of dry matter intake by kids fed rations with DPL as the main protein source but without molasses added to the rations.

DPL was included at 0%, 20%, 25% and 30%. From the feeding trial the control ration that contained 0%DPL maximum dry matter intake was recorded. With the other three rations an increase in DPL resulted in a decrease in dry matter intake. Since molasses was not incorporated in the rations, this was suspected to be the cause of low dry matter intake as DPL level of inclusion advanced. The same findings were reported by Nadeem *et al.*, (1992) in sheep fed DPL based rations as a substitute of CSC but without any molasses incorporated in the rations and poor feed conversion ratio (FCR) was inevitable.

Adegbola *et al.* (2009) found high feed intake from the feeding trials of fattening bulls and fattening African dwarf sheep in Mauritius. Molasses was the main energy source and the daily feed intake increased from 7 kg/ day initially to 12 kg/ day by the end of the feeding trial. An average daily weight gain of 0.65 kg/ day was observed. Adegbola *et al.* (2009) also found that there were no statistically significant differences on feed intake by African dwarf sheep fed rations containing DPL substituting wheat offals and ground nut meal at 0%, 25%, 50%, 75% and 100%.

In a feeding trial of cat fish carried out in Nigeria where DPL replaced soya bean meal at 20%, 40%, 60%, 80% and 100% levels, fish became accustomed to the experimental diets within a period of seven days of acclimation. No significant differences were recorded in feed intake (Obasa *et al.*, 2009).

2.6 Effects of DPL from feeding trials carried out from different parts of the world

Dewormed fattening steers with an average induction weight of around 250kg fed a DPL based ration at inclusion levels of 25%, 50%, 65% and 75% with maize as the main energy source gained an average of 1.5 kg/day (Cross, 1995). DPL inclusion in fattening cattle diets proved to be cost effective since animals from the feeding trial gained weight comparable to some animals from the contemporary group fed conventional diets and gained weight ranging from 1.2-1.6 kg/day. Cross (1995) also revealed that DPL's fibre was very effective in preventing lameness in penned cattle. The amount of hay and other roughages required for conventional feeds were reduced by DPL. Veld finishing steers that were supplemented DPL and maize on a 50:50 basis gained an average of 1 kg/ day and this reduced the cost of plant protein sources (Evers *et al.*, 1996).

No significant effects were reported on meat quality and grades and even milk composition and flavour from animals fed rations containing DPL (Fontenot, 1996; Fontenot and Hancock, 2001). In a study carried out by Fontenot and Hancock (2001) beef cattle fed rations containing DPL as the sole protein source performed similar to their counterparts fed conventional rations and the carcass quality and meat taste were not adversely affected by DPL inclusion in the formulated rations.

Belewu (1997) reported that DPL inclusion at 60% level resulted in 50.16 MJ ME intake per day in fattening beef cattle. CP digestibility was measured and found to be 74.4%. Similar results were obtained by Belewu and Adneye (1996). Increased average daily weight gains were recorded at inclusion rates of DPL between 40 and 60%. Milk yield from rations containing DPL up to 60% averaged 12.8 litres/ head/ day from cows fed 5 kg / head / day being 3% higher than the yield from conventional diets.

DPL replaced up to 60% soya bean meal in African cat fish diets and proved to have no adverse effects on growth rate and nutrient utilisation (Obasa *et al.*, 2009). DPL inclusion up to 60% resulted in the same growth rate of African cat fish as the conventional feeds but at a much more reduced cost.

In a feeding trial carried out by Nadeem *et al.* (1993) with 4 inclusion levels of DPL (0%, 20%, 25% and 30%), blood serum samples showed an increase in sodium, potassium and nitrogen as the inclusion level increased. Calcium and phosphorus that met dietary requirements were observed from 30% DPL inclusion level. Evers *et al.* (1996) found that DPL had the greatest economic value as a protein and mineral supplement and excess supply of calcium, phosphorus, potassium, copper, iron and magnesium was reported from DPL. At 80% inclusion level 5 times more calcium, phosphorus and potassium was observed (Rankins, 2000). Calcium to phosphorus ratio of (1.2:1) was reported indicating that diets based on 60% DPL inclusion are well balanced in these 2 elements.

McDonald *et al.* (2010) reported that dietary inclusion rates of up to 25% per tonne for dairy cows and up to 40% per tonne for fattening beef cattle have been used and have supported acceptable levels of performance. In feeding trials when DPL substituted 50% soya bean meal for dairy cows rations 20 kg milk yield was achieved the same as the control ration thus reducing the costs of soya bean meal by 50%.

2.7 Poultry industry in relation to DPL output

Morokolo (2012) reported that production of broiler meat increased continuously from 2004 to 2011 in Africa by 36%. In Nigeria about 932.5 metric tonnes of poultry litter are produced annually from the well-established poultry industries which keep expanding at a rate of 8%

per year (Adewuni, Adewuni and Olaleye, 2011). Gueye (2003) stated that poultry and cattle are the most numerous species of farm animals in Africa which recorded 23% growth in chicken slaughter and 15% increase in egg production between 1990 and 1998. Poultry industry continued to expand and many African governments supported the poultry industry in the form of distribution of improved day old chicks, feeds, promotion of the setting up of local hatcheries and provision of technical support for example in Senegal (Gueye, 2003).

DPL output is guaranteed since poultry production is one of the largest and fastest growing agro-based industries (Bolan *et al.*, 2010). According to the United States Department of Agriculture (USDA), (2008) 8.9 million broilers were produced in USA in 2008 with a total of 44.4 million tonnes of manure output produced the same year and in New Zealand approximately 81 million broilers were produced in 2008 and from such birds 591300 tonnes of manure were produced (Bolan *et al.*, 2010). Globally poultry production had gone up by 35% from the year 2000-2008 (Ghaly and McDonald, 2012). The world's estimated flock in 2010 was 18 billion birds with an average of 22 million tonnes of manure output annually (Bolan *et al.*, 2010)

CHAPTER THREE

MATERIALS AND METHODS

3.0 Location of study

This study was conducted at New Donnington Farm during the period from 25th November 2013 to 23rd February 2014. The farm is located 18^0 01'S latitude and 30^0 34'E longitudes with an elevation of 1380 m above sea level. The farm is situated in Mashonaland West Province in Chegutu Rural District, Agro ecological region 2 of Zimbabwe. Annual rainfalls range between 750 and 1000 mm, summer temperatures range from 18-25^0C whilst winter temperatures range between 15 and 18^0C (Makodza, 2013).

3.1 DPL collection and treatment

Poultry litter from deep litter poultry houses at New Donnington Farm was collected 3 days after broiler batches were cleared. The poultry litter was sun dried for 8-10 hours/ day for 3 days by spreading to a thickness of approximately 1 cm on polythene sheets on a concrete base. Drying was terminated when the poultry litter reached the moisture content of 12% as determined by the Near Infra-red Reflectance Spectroscopy (NIR) (DA7200) before being incorporated into the experimental diets. Composite samples of all the ingredients including DPL were collected and analysed for chemical composition using the NIR DA7200 on the farm. The composite samples were also analysed for energy levels. White maize and cotton seed cake were ground by a hammer mill using a 2 mm sieve.

3.2 Animals management

Thirty Brangus steers of approximately same age (18 months) and weight (300±5 kg) were selected from the herd. The selected steers were vaccinated against botulism using a 3 in 1 vaccine (Prondistar®) at a rate of 2 ml/ head subcutaneously. Prondistar® is a vaccine for protection against anthrax, botulism and black leg. The steers were dewormed against liver flukes, tapeworms, roundworms and lungworms with Albex® at a rate of 1 ml Albex® per 10 kg body weight. Albex® contains 10% w/v Albendazole as the active ingredient. The steers were injected Vitol Ject- Forte® for the prevention of vitamins deficiencies at a rate of 1 ml/ 5kg body weight via the intramuscular route. Vitol Ject- Forte® contains Vitamins A, B_1, B_2, B_6, B_{12}, C, D_3, E, Panthenol and Nicotinamide per 1 millilitre (ml). Finally the steers were hand sprayed Decatix® acaricides for the control of ticks, biting flies and nuisance flies.

Decatix® contains the active ingredient Deltamethrin 5% m/v and also Decatix® belongs to synthetic pyrethroids stock dips with long residual effects. Decatix® was applied at a rate of 10 ml Decatix® to 1 litre water and was applied liberally.

The steers were fed at a rate of 3% of their body weights. Steers received their diets in equal parts twice per day, the first half in the morning at 7.30 am and the remaining half was supplied at 1.30 pm. Steers were adapted to the diets for 14 days to avoid digestive disturbances. The weights were collected for 90 days during which time the steers were weighed fortnightly in a crush pen using a 1000 kg scale that was first calibrated using standardised 50 kg weights. Katambora hay, maize sheath and stover and clean drinking water were provided *ad libitum*. The feed and water troughs were cleaned on daily basis before feeding the steers.

3.3 Ration formulation

The computer method formula was used to formulate the experimental diets. A digital scale was first calibrated using 5 kg, 10 kg, 20 kg and 50 kg standard weights before weighing the ingredients which were incorporated into the rations. Five Isoenergetic (12.50 MJ ME/ kg) and Isonitrogenous (16% CP) diets were formulated. DPL (26% CP) replaced CSC (31% CP) in the control ration on protein to protein basis at 0%, 25%, 50%, 75% and 100% levels as shown in **Table 2**.

Table 2: Ingredients' inclusion levels (%) of 5 different experimental diets ($T_1 – T_5$)

Ingredients (%)	T_1	T_2	T_3	T_4	T_5
White maize	65	66	67.25	68	68
Cotton Seed Cake	20	15	10	5	0
Dried Poultry Litter	0	5	10	15	20
Mabiko K	3	3.1	3.2	3.27	3.34
Molasses	3	3.1	3.2	3.25	3.27
Mono Calcium Phosphate	1	1	1	1	1
Katambora (Roughage)	3	2	1	1	1
Sodium Chloride	1	1	1	1	1
Water	4	3.8	3.35	2.48	2.39
	100	100	100	100	100

T_1 = Treatment 1 ingredients, T_2 = Treatment 2 ingredients, T_3 = Treatment 3 ingredients, T_4 = Treatment 4 ingredients and T_5 = Treatment 5 ingredients

After formulating all the experimental diets 3 composite samples which were a true representative were collected from each of the 5 formulated experimental diets for analysis.

3.4 Experimental design

Six steers were allocated completely at random to each experimental diet. Each steer was considered as a replicate whilst the 5 formulated diets were the treatments. Each treatment was replicated 6 times with 6 steers (replicates) in a completely randomised design (CRD) (Obasa *et al.*, 2009; Adesehinwa *et al.*, 2010; Hassan, Yassin and Gibril, 2013; Bello and Tsado, 2014). The steers were housed individually in pens.

3.5 Data collection and statistical analysis

Cumulative weight gain, average daily gain and feed conversion ratio (FCR) were calculated and recorded fortnightly for individual replicates and for each treatment. The data were subjected to one way analysis of variance (ANOVA) using Statistical Analysis System (SAS) and the least significance difference (LSD) was used to separate the means. The costs of formulated rations were compiled based on the ingredients incorporated.

CHAPTER FOUR

RESULTS

The mean daily feed intake per steer was almost uniform for 30 steers and averaged 10 kg/ steer/ day for 90 days. Total weight gain (TWG), Average daily gain (ADG) and Feed conversion ratio (FCR) were highest for Treatment 1 (T_1) (Control) and lowest for Treatment 5 (T_5). The differences in TWG, ADG and FCR for all the treatments were statistically significant ($p>0.05$) and are presented in **Table 3**. ADGs for T_1, T_2, T_4 and T_5 did not show any consistence throughout the feeding trial since they were fluctuating. The trends for ADG are illustrated in **Figure 1**.

Table 3: Effects of feeding 5 different levels of DPL based diets on ADG, TWG and FCR of Brangus steers

Treatments	TWG	ADG	FCR
1	126^{a}	1.4^{a}	7.15^{a}
2	120^{b}	1.3^{b}	7.48^{b}
3	109^{c}	1.2^{c}	8.23^{c}
4	82^{d}	0.9^{d}	11^{d}
5	51^{e}	0.6^{e}	17.7^{e}
p Value	<0.0001	<0.0001	<0.0001
SEM	5.19	0.06	0.73
LSD	1.26	0.01	0.18
CV%	29.11	29.09	38.87

Means bearing different superscripts in the same column are significantly different ($p>0.05$), SEM = Standard Error of Means, LSD = Least Significant Difference and CV = Coefficient of Variation

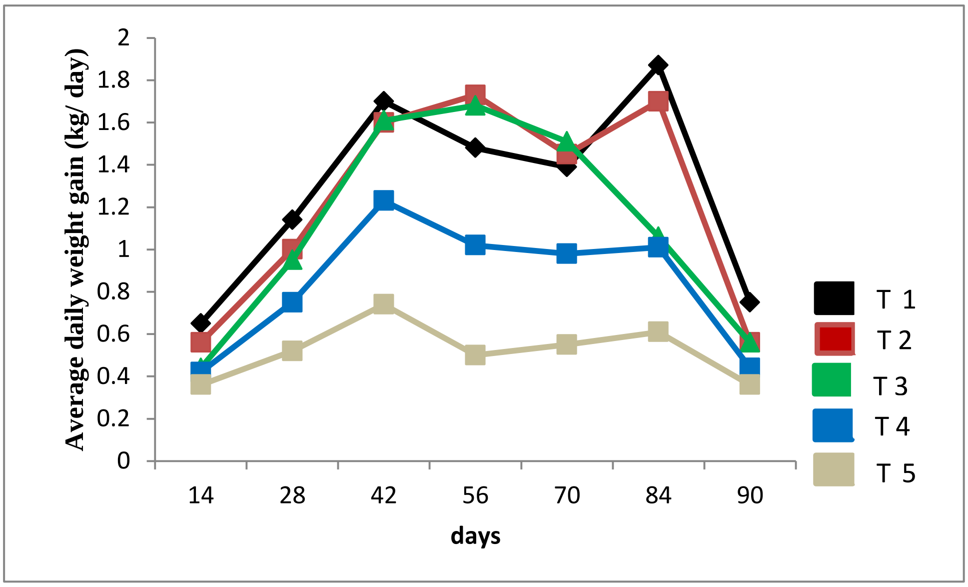

Figure 1: Trends of ADG from 5 formulated experimental diets fed to steers

T1 = Treatment 1, T2 = Treatment 2, T3 = Treatment 3, T4 = Treatment 4, T5 = Treatment 5

Initially the ADGs for T_1 and T_2 were not significantly different (p<0.05) whilst ADGs for T_3, T_4 and T_5 were not significantly different (p<0.05) but were significantly different (p>0.05) from ADGs T_1 and T_2. After 28 days the ADGs for T_2 and T_3 were not significantly different (p<0.05) but were significantly different (p>0.05) from T_1, T_4 and T_5 ADGs. On day 42 there was no significant difference (p<0.05) from ADGs of T_1, T_2 and T_3 but were significantly different (p>0.05) from ADGs of T_4 and T_5.

After 56 days, T_1, T_4 and T_5 ADGs were significantly different (p>0.05) and were also different from T_2 and T_3 ADGs which were not significantly different (p<0.05). On day 70, ADGs for T_1, T_2 and T_3 were not significantly different (p<0.05) but were significantly different (p>0.05) from T_4 and T_5 ADGs. ADGs of T_1, T_2 and T_5 were significantly different (p>0.05) whilst there was no significant difference (p<0.05) between ADGs of T_3 and T_4 on day 84. Finally on day 90 there was no significant difference (p<0.05) from ADGs of T_2, T_3 and T_4 and also there was no significant difference (p<0.05) between ADGs of T_4 and T_5. T_1 ADG was significantly different (p>0.05) from ADGs of the other four treatments.

From the beginning of the feeding trial, the ADGs in all the 5 treatments were increasing up to day 42 with maximum ADG from T_1, followed by T_2 and T_3 ADGs. Throughout the feeding trial ADG from T_5 was the least followed by the ADG from T_4. ADGs for T_1, T_4 and T_5 started to decline after day 42 whilst ADGs for T_2 and T_3 continued to increase up to day

56 when the two ADGs started to decline. The ADG for T_3 continued to decline up to the end of the feeding trial. After day 70 the ADGs for T_1 and T_2 started to rise again up to day 84 when the two ADGs started to decline up to the end of the feeding trial. After day 56 the ADG for T_5 started to increase again up to day 84 when the ADG started to decline up to the end of the feeding trial. ADG for T_4 started to decline slightly after day 56 up to day 70 when the ADG started to increase slightly up to day 84 when the ADG finally declined.

The economic evaluation of fattening rations of steers is presented in **Table 4** below.

Table 4: Economic evaluation of 5 different rations fed to Brangus steers

Ingredient	Price US $/ Tonne	T_1 Costs US $	T_2 Costs US $	T_3 Costs US $	T_4 Costs US $	T_5 Costs US $
Maize	267	989	1004	1023	1034	1034
CSC	350	399	300	200	100	
Mabiko K	432	74	76	79	81	82
MCP	260	15	15	15	15	15
Sodium Chloride	190	11	11	11	11	11
Molasses	280	48	49	51	52	52
Roughage	200	34	23	11	11	11
DPL	60		17	34	51	68
Total Costs		1570	1495	1424	1355	1273
Cost/ Steer		262	249	237	225	212

T_1 = Treatment 1 (0% DPL), T_2 = Treatment 2 (25% DPL), T_3 = Treatment 3 (50% DPL), T_4 = Treatment 4 (75% DPL), T_5 = Treatment 5 (100% DPL), CSC = Cotton seed cake, MCP = Monocalcium phosphate, DPL = Dried poultry litter

From the table above, an increase in DPL inclusion levels resulted in a reduction of total costs of the formulated rations which in turn reduced the feed cost/ steer.

CHAPTER FIVE

DISCUSSION

5.0 Average daily gains (ADG) over time

The ADGs from this study are in agreement with the findings of Lanyasunya *et al.* (2006) on the performance of Holstein bulls fed 3 levels of DPL (0%, 15% and 30%). The ADGs of the bulls declined with an increased rate of DPL inclusion. Also the findings of this study agree with the findings of McDonald *et al*. (2010). McDonald *et al*. (2010) found that fattening steers fed diets containing DPL gained at least 1 kg/day. From this study 0%, 25% and 50% DPL inclusion levels yielded 1.4, 1.3 and 1.2kg/day respectively which are in agreement with the findings of McDonald *et al*. (2010). Reduced ADGs for Treatments 4 and 5 in this study were also reported by McDonald *et al*. (2010) in dairy cows fed diets containing 50% DPL and gained 0.58 kg/day against the expected 0.95 kg/day from the conventional diets of plant protein sources (CSC and soya bean meal). McDonald *et al*. (2010) estimated 40g/kg decline in ADGs for every 100kg/tonne DPL inclusion in fattening rations.
The ADGs from this study up to day 42 also agree with the findings of Owens, Dubeski and Hanson (1993). ADGs for Treatments 1, 2, 3 and 4 can be related to self-accelerating phase of the growth curve after the steers grazed poor quality forages during the hot and dry season without supplementation. Generally during the dry season the nutritional value of forages decline although the nutritional value was not measured for this study. The rate of ADGs after the steers were put in feedlots was faster and this could be associated with rapid hypertrophy of muscle tissue as a result of more energy above maintenance (Owens *et al.,* 1993).

However from this study the ADG from Treatment 5 was very much reduced compared to other ADGs. Considering that the steers were all exposed to grazing for the same period, low ADGs from Treatment 5 followed by Treatment 4 could be as a result of poor utilisation of DPL by steers at higher inclusion rates in the diets. Low ADGs from this study are in agreement with the findings of Harrison and Karnezos (2005) who found that Non Protein Nitrogen (NPN) based diets where urea was the sole protein source resulted in reduced ADGs. Harrison and Karnezos (2005) reported that the microbial protein formed was inadequate for the high requirements of growing fattening cattle.

The ADGs from this study are in contrast with the findings of Belewu (1997) in which the ADGs were positively correlated to increased DPL inclusion in the diets. Belewu (1997) feeding trial contained DPL as the sole protein source in all the experimental diets except for the control which did not contain any plant protein source. DPL inclusion was not compared to plant protein sources like in this study. Belewu (1997) study was based on determining the optimal level of incorporating DPL as the sole protein source in steers' fattening rations and that is why high ADGs were attained at 60% DPL inclusion level.

The declines in ADGs from day 42 to day 70 from this study agree with the findings of Kebede, Bitew, Bimrew, Yitayew, Denekew, Ferede and Zeleke (2013). ADGs decline could be as a result of drastic weather changes from warm temperatures to cool and humid weather conditions during the feeding trial for 2 weeks. Heavy rains which resulted in wet muddy pens were also received. Musemwa, Muchenje, Mushunje and Zhou (2012) revealed that decreasing temperatures do have impacts on beef production because the metabolic response to cold temperatures involves practically all the systems of the body. Striated muscles shiver, the heart beats faster, breathing becomes deeper, urine flow is increased and the sympathetic and pituitary controlled systems are activated to elevate heat production in all body tissues. More energy will be channelled towards maintenance at the expense of growth. The decline in ADGs could be either as a result of reduced intake of energy above maintenance since the concentrates were not fed *ad libitum* or environmental stress (Koknarogln, Loy and Hoffman, 2005).

After day 84 the rates of ADGs for Treatments 1, 2, 4 and 5 started to decline up to day 90. For Treatments 1, 2 and 3 this could be related to the self-decelerating phase of growth and such declines agree with the findings of Owens *et al*. (1993) and Kebede *et al*. (2013). The animals could have reached their genetic potential weight at that particular age (21 months). The decelerating phase is characterised by an inbuilt restraint on further growth, which progressively result in fat deposition for energy above maintenance (Lawrence and Fowler, 2002). Logically the ADGs from Treatments 4 and 5 were expected to continue increasing so as to reach almost the same maximum ADGs like Treatments 1, 2 and 3. Considering that the steers were of same age, exposed to same environmental conditions prior to fattening and were fed Isoenergetic and Isonitrogenous diets then the differences in ADGs with time could be related to poor utilisation of DPL at high inclusion rates in the diets.

5.1 Total weight gain (TWG)

The TWGs of this study are in agreement with the findings of Talib and Ahmed (2008) who also found reduced TWG with increased DPL inclusion in the diets. TWG was highest for the control (0% DPL) and least for 60% which was the maximum DPL inclusion rate. From Talib and Ahmed (2008) the average daily feed intake was uniform in all the experimental diets and this can be attributed to high palatability of the diets. Nadeem *et al.* (1993) and Ndubueze, Ukachukwu, Ahemufule and Ibeawuchi (2006) also found reduced TWGs with increased DPL inclusions in the diets. From this study feed intake was also uniform across all the treatments most probably because molasses which enhance palatability was incorporated in the diets. In a study by Talib and Ahmed (2008) the fattening bulls gained weights of 100, 98, 96 and 81kg for 0, 20, 40 and 60% DPL inclusions in the diets respectively fed for 98 days. The TWGs deteriorated gradually as DPL inclusion rates increased indicating that NPN alone could not maximise microbial growth. Deterioration could be due to lower energy density of DPL compared to other ration ingredients.

DPL inclusion at 25% from this study could have influenced optimal release of ammonia and energy in the rumen for microbial protein synthesis than 50, 75 and 100% DPL inclusion levels in the diets. Since DPL had partially replaced CSC some dietary protein could have escaped rumen degradation and was utilised in the abomasum together with the microbial protein resulting in increased TWGs. Higher DPL inclusion (50-100%) in the diets could have resulted in imbalance to the proportions of ammonia and energy in the rumen resulting in loss of ammonia through urea which negatively influenced protein utilisation and subsequently weight gain in the steers (Ndubueze *et al.*,2006; Talib and Ahmed, 2008).

Reduced TWGs from high DPL inclusion in the diets from this study can be related to the findings of Harrison and Karnezos (2005). Several species of rumen bacteria require specific amino acids for their growth. Bacteria utilise peptides, amino acids and ammonia for their growth whilst protozoa cannot utilise ammonia. Improved microbial growth and feed efficiency have been noted when preformed amino acids replaced urea as the sole nitrogen source. Rumen microbes that ferment non-structural carbohydrates obtain about two thirds of nitrogen from preformed amino acids or peptides whilst fibre digesting bacteria derive all their nitrogen from ammonia. Higher concentrations of ammonia limit the growth of cellulolytic microorganisms and reduce rumen fibre digestion and microbial protein production (Harrison and Karnezos, 2005).

The TWGs from this study are in contrast with the findings of Hadjipanayiotou *et al.* (1993) and Mavimbela (2000) in which there were no significant differences in TWGs from the conventional diets and DPL inclusions of 33% and 45% respectively. Relative to the amount of CP in DPL, the available energy might be insufficient for the rumen microbes to utilise the nitrogen (Van Ryssen, 2001).

5.2 Feed conversion ratio (FCR)

FCR which is the quantity of feed required to produce one unit (1 kg) gain ranged from 7.15-17.7 kg in this study. The lower the FCR, the most efficient the feed value consumed by the animal. From this study, the FCR increased as DPL inclusion was also increased in the diets. This indicate that steers fed 25% DPL ration utilised their feed better than the steers fed 50, 75 and 100% DPL rations since a smaller value of feed to gain ratio shows the efficiency of utilisation of feed by an animal. This is in agreement with the findings of Lanyasunya *et al*. (2006) and Madziga, Alawa, Lamidi, Goska and Adesote (2013). The Non Protein Nitrogen in DPL must be first converted into urea and then into ammonia inorder to be utilised by the animal. The conversion to urea is usually a slow process and wastage (McDonald *et al.*, 2010). Zinn *et al*. (1996) also reported that the rate of degradation of uric acid in DPL based on ammonia accumulation is apparently much slower than that of urea.

5.3 Economic benefits

From this study the inclusion of DPL in the fattening diets reduced the costs of ration formulation. DPL inclusion reduced the quantities of CSC and roughage thus minimising the costs of such ingredients in the diets of fattening cattle. Cost reductions in this study are in agreement with the findings of Hadjipanayiotou *et al*. (1993); Obasa *et al*. (2009) and Lanyasunya *et al*. (2006). The 25% DPL inclusion in this study reduced the fattening costs per steer by 5% and the ADG (1.3 kg/ day) is within the recommended weight gain range (1.2 – 1.6 kg/ day) used for fattening cattle in Zimbabwe (Moyo, 1996).

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.0 Conclusion

On the basis of the findings of this study it can be concluded that DPL is a low quality feed ingredient that reduces ADG, TWG and feed conversion efficiency at higher inclusion levels (50-100%) in the fattening rations of beef cattle. Feed costs are reduced only at low levels of inclusion in the diets (25%) where DPL does not have adverse effects on steers' performance.

6.1 Recommendations

DPL inclusion in fattening beef cattle diets should not exceed 25% since it can only partially replace plant protein sources like CSC on protein to protein basis.

List of Appendices

Appendix A: Statistical Analysis for the Average Daily Gain (ADG)

N	30	Sum Weights	30
Mean	1.08533333	Sum Observations	32.56
Std Deviation	0.31570101	Variance	0.09966713
Skewness	-0.6683756	Kurtosis	-1.0714634
Uncorrected SS	38.2288	Corrected SS	2.89034667
Coeff Variation	29.0879307	Std Error Mean	0.05763885

Alpha	0.05
Error Degrees of Freedom	24
Error Mean Square	0.000139
Critical Value of t	2.06390
Least Significant Difference	0.0141

Appendix B: Statistical Analysis for the Total Weight Gain (TWG)

N	30	Sum Weights	30
Mean	97.6333333	Sum Observations	2929
Std Deviation	28.4259271	Variance	808.033333
Skewness	-0.6752861	Kurtosis	-1.0610635
Uncorrected SS	309401	Corrected SS	23432.9667
Coeff Variation	29.1149817	Std Error Mean	5.1898405

Alpha	0.05
Error Degrees of Freedom	24
Error Mean Square	1.115799
Critical Value of t	2.06390
Least Significant Difference	1.2587

Appendix C: Statistical Analysis for Feed Conversion Ratio (FCR)

N	30	Sum Weights	30
Mean	10.3167982	Sum Observations	309.503945
Std Deviation	4.00996631	Variance	16.0798298
Skewness	1.17928848	Kurtosis	-0.1781495
Uncorrected SS	3659.40479	Corrected SS	466.315065
Coeff Variation	38.8683219	Std Error Mean	0.73211633

Alpha	0.05
Error Degrees of Freedom	24
Error Mean Square	0.021949
Critical Value of t	2.06390
Least Significant Difference	0.1765

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