EVALUATION OF LOCALLY AVAILABLE FEED RESOURCES FOR CATTLE FATTENING UNDER TRADITIONAL FEEDLOT PRODUCTION SYSTEM IN KAHAMA AND MISUNGWI DISTRICTS, TANZANIA

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ABSTRACT

Two studies were conducted to assess utilization of locally available feed ingredients for cattle fattening under traditional feedlotting system in North Western Tanzania. The first study involved identification of feed materials used for fattening in Misungwi and Kahama districts. Information on feed materials and diet formulation used by cattle fatteners were collected through focus group discussion. The feeds identified were analysed for chemical composition. In the second study, an on-station feeding experiment was conducted to assess the suitability of locally available feeds for cattle fattening. A total of 40 Tanzanian Shorthorn Zebu bulls with the age of three to four years and average weight of 172.6 ± 6.1 kg were used in the experiment. The animals were allocated to five dietary treatments (T_1, T_2, T_3, T_4 and T_5) in a completely randomized design and the experiment took 70 days. Four animals were randomly assigned to each dietary treatment and each treatment was replicated twice. The ingredients of fattening diets were maize meal (MM), molasses (ML), maize bran (MB), rice polishing (RP), cotton seed hulls (CSH) and cotton seed cake (CSC). The compositions of the diets were as follows: T_I (38% MM, 47% ML+ 0.5% urea), T_2 (45% MB, 37% CSH), T_3 (37% CSH, 45%RP), T_4 (30% CSH, 30% RP, and 22% MB) and T_5-control (83.5% CSH + 1.5 local salts). Cotton seed cake (CSC) was used as a source of protein and comprised 13% of diet T_1 and 15% of T_2, T_3 and T_4 diets. All diets were provided to the animals in adlib amount after grazing. Average feed intake (AFI), feed conversion ratio (FCR), average daily weight gain (ADG) and gross margin (GM) were determined. The results for focus group discussion show that CSH, CSC, MB and RP were the major feed ingredients used by local farmers for fattening. The majority (35.0%) of the respondents were using a diet composed of the mixture of CSH and CSC, but some were using either a mixture of CSH and RP (21.7%) or CSH alone (18.3%) to fatten cattle. In the feeding trial, AFI (5.58 kg DM/d) and FCR (10.27) were highest ($P < 0.05$) for the bulls fed T_5. The highest ADG was observed on the bulls fed T_1 diet (0.90 kg/d) and differed ($P \leq 0.05$) from that of animals fed T_3 (0.61 kg/d) and T_5 (0.58 kg/d), but not with the ADG of animals on T_2 (0.86 kg/d) and T_4 (0.83 kg/d) .The bulls fed T_1 had the highest ($P < 0.05$) cost per unit weight gain (3 337 TZS) and lowest GM (-58 661 TZS) whereas those on T_4 had the lowest ($P \leq 0.05$) cost per unit weight gain (1 340 TZS) and highest GM (66 834 TZS). It is concluded that, the treatment diet T_4 is better than the other diets in traditional cattle fattening systems.

DECLARATION

I, Alex Goodluck Mrema, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

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Alex Goodluck Mrema Date

The above declaration confirmed by;

_______________________ ________________

Prof. S.W. Chenyambuga Date

(Supervisor)

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This work is dedicated to my parents Mzee Maleto and my beloved late mother Mama Mashina, humbly together took the responsibility of laying down the foundation of my educational pillar. “May the Almighty God rest her soul in eternal peace and give my father long life, Amen”.

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LIST OF ABBREVIATIONS

^0C	Degree Celsius
ADF	Acid Detergent Fibre
ADG	Average Daily Gain
ADL	Acid Detergent Lignin
AFI	Average Feed Intake
AOAC	Association of Official Analytical Chemists
BCS	Body Condition Score
CF	Crude Fibre
CP	Crude Protein
CSC	Cotton seed Cake
CSH	Cotton seed Hulls
d	Day
DASP	Department of Animal Science and Production
DM	Dry matter
E	East
EC	Emulsifiable Concentrate
EE	Ether Extract
FAO	Food and Agriculture Organisation of the United Nation
FCR	Feed Conversion Ratio
FFS	Farmers Field School
FGD	Focus Group Discussion
g	Gram

GI	Gross Income
GLM	General linear model
GM	Gross Margin
ha	Hectare
INVDMD	InVitro Dry matter Digestibility
INVOMD	In Vitro Organic matter Digestibility
kg	Kilogram
km	Kilometre
m^2	metre squared
MB	Maize Bran
ME	Metabolizable Energy
MJ	Mega Joules
MLFD	Ministry of Livestock and Fisheries Development
MM	Maize meal
NARCO	National Ranching Company
NDF	Neutral detergent Fibre
NFE	Nitrogen free Extract
NRC	National Research Centre
RP	Rice Polishing
S	South
s.e	Standard Error
SAS	Statistical Analysis System
SPSS	Statistical Package for Social Sciences
SUA	Sokoine University of Agriculture

TALIRI	Tanzania Livestock Research Institute
TZS	Tanzanian Shilling
TZSZ	Tanzanian Shorthorn Zebu
VC	Variable Costs

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Most of the meat consumed in Tanzania comes from indigenous cattle breeds, which are the Tanzania Shorthorn Zebu (TZSZ) and Ankole cattle. It is estimated that about 3 050 000 cattle, 3 000 061 goats, 1 725 000 sheep are slaughtered annually countrywide, producing about 346 654 tonnes of meat annually (FAO, 2013). In Tanzania, more than 90% of beef is produced from extensive production system which is characterized by low input supply in terms of feeds, veterinary drugs and general management (Njombe and Msanga, 2009; Mawona, 2010). Beef production under the extensive system is affected by shortage of forage, especially during the dry season as animals depend entirely on natural pastures (Chamatata, 1996). During the dry season, the quantity and quality of natural pastures are low and animals fed on these pasture have low growth rate, poor body condition score and are emaciated, and thus produce low quality meat (Wileman *et al*., 2009; Frylinck *et al*., 2013). Poor quality meat fetches low price in the markets, hence, low income to farmers and other stakeholders (Mkonyi *et al*., 2006; Pica-Ciamara *et al*., 2011; Mlote *et al*., 2012; Malole, 2013).

The meat produced in the country is mainly used for local consumption and little is available for export (MLFD, 2009). With recent growth of tourism, expanding mining and manufacturing industries and establishment of international hotels in Tanzania, the demand for quality meat in urban areas, notably the supermarkets, is expected to increase (Madsen *et al*., 2008; Mlote *et al*., 2012; Malole, 2013). Therefore, there is a need to improve beef production from the traditional livestock sub- sector through adoption of improved and affordable production and processing technologies. Meat production can be increased through improved husbandry practices and provision of basic inputs to traditional livestock keepers (Steinfeld *et al*., 2006; Webb, 2013). Fattening is one of the beef production systems whereby animals are intensively fed high nutritious feeds (high-energy diets) for a short period in order to attain desired market live weight and body conditions (Creek and Squire 1976; Weisbjerg *et al*., 2007). Fattening practices are mainly practiced by Tanzania's commercial ranches (NARCO) and privately owned large-scale farms (MLFD, 2010). However, there are few small-scale livestock keepers and traders who mostly fatten mature cattle. Conventional concentrates such as cereal grains, molasses, oil cakes and other cereal agro-industrial by-products are used to improve performance of animals under fattening (Chamatata, 1996). Unfortunately conventional concentrates have two major limitations; first the ever-increasing price, and secondly, limited supply of cereal grains due to competition for use as human food (Mawona, 2010; FAO, 2013). Hence, it is imperative to look for alternative local feed resources which are relatively cheap and readily available. This may reduce production costs of beef and at the same time lead to producing quality meat.

1.2 Problem Statement and Justification

In recent years, cattle fattening has emerged as a method for value addition of indigenous cattle breeds in Shinyanga, Simiyu and Mwanza regions (MLFD, 2009; Mawona, 2010). Fattening in these areas is used to add value to cattle purchased directly from pastoralists and agro-pastoralists (Madsen *et al*., 2008). Normally livestock traders buy animals of lower grades and at lower prices from producers in the primary livestock markets and feed them with cotton seed cake, cotton hulls, rice polishing and/or maize bran for three to four months before selling at higher prices in secondary and tertiary markets or slaughter houses (Mlote *et al*., 2012). Under the traditional cattle fattening system, animals are fed *adlibitum* amount of these agro-by-products. This feeding practice is usually uneconomical, especially with rising costs of the feeds.

In the past cotton hulls, rice polishing and maize bran were readily available, cheap and could sometimes be costless with no economical value attached to these materials. Consequently, they were regarded as wastes causing social and environment concerns (Chamatata, 1996). Due to increasing practice of cattle fattening in Mwanza and Shinyanga regions, the demand and price of these agro-by products have increased (Mlote *et al*., 2012). This necessitates planning for their optimal and efficient use in order to obtain optimum animal performance and maximise profit.

So far, there is no research that have been done in the Lake zone, in particular Kahama and Misungwi districts, to establish or determine the optimum inclusion levels for the various locally available feed materials in cattle fattening rations. Moreover, there is no standard diet recommended for cattle fattening under the traditional sub-sector (Nandonde, 2008; Mawona, 2010). The type of feed materials and their amount used in the diets vary considerably among cattle fattening operators, leading to finished animals having different qualities. Therefore, there is a need to formulate a cheap and well-balanced concentrate diets (that will meet beef cattle nutrient requirements) based on locally available feed resources in order to enable farmers to produce beef more economically and efficiently. This will result into increased production of quality meat, and hence, increase the profitability of traditional fattening system. Therefore, the current study was undertaken with the aim of optimizing the utilization of locally available feedstuffs through formulation of cheap diet that meet nutritional requirements for improved performance of indigenous cattle fattened under the traditional feedlot system. Specifically the study aimed:

(i) To identify the locally available feedstuffs used for cattle fattening under traditional feedlot system in Kahama and Misungwi districts and assess their nutritive values.

(ii) To compare feed intake, feed conversion efficiency, weight gain and body condition score of bulls finished using a common local diet used by farmers and formulated balanced diets.

(iii) To compare the gross margins of feedlot practices done using a common local diet under farmers practice and formulated balanced diets.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview

Fattening is one of the beef production systems whereby animals are intensively fed high nutritious feeds (high-energy diets) for a short period with the aim of attaining market live weight and body conditions in a short period. Fattening improves meat quality and consumer preference; hence, animals are sold at higher prices and large profit is obtained. Under this production system, desired animals may be finished under total confinement (feedlotting) or allowed to graze and supplemented with concentrate feed for ninety days. In Tanzania, there are two major types of cattle fattening system, traditional and commercial (MLFD, 2009). Either of the system when practiced under good management using appropriate technologies is economically worthy.

2.1.1 Traditional feedlotting system

In the traditional production system, individual livestock keepers and traders fatten cattle through grazing and supplementation with agro-industrial by-products. The efficiency and number of fattened animals is normally small and varies seasonally due to production constraints such as inadequate capital, lack of proper management skills and feed shortage (Asizua *et al*., 2009; Mlote *et al*., 2012). It is estimated that only one to two tons DM/ha of forage biomass is available for free range beef production systems in arid and semi-arid areas where traditional cattle fattening is mostly practiced (MLDF, 2009). This amount of forage is not sufficient to promote beef production in traditional sub-sector where livestock feeding relies on grazing only. However, in many places forage shortage is sometimes compensated by the use of crop residues after crop harvest. The most commonly used are the cereal crop residues which are low in nutritive values.

In order to obtain maximum intake and performance of beef cattle grazed in rangeland forages, Minson (1990) recommended that a minimum of 3.6 tons DM/ha is required for better performance. In order to attain such biomass production, the rangelands available for grazing need to be improved. However, rangeland improvement is not a feasible approach in communal areas due to adverse climatic conditions, poor infrastructure and antagonizing social-economic factors such as land use conflicts and poor tenure systems. Thus, improving the performance of fattened animals through supplementation using available feed resources is the best option. Fattening using a combination of grazing and supplementation with concentrate diet made from locally available feed resources can improve animal growth performance and increase the financial benefits of cattle fattening under small-scale production system (Webb, 2013).

2.1.2 Improved or commercial feedlotting system

Under improved commercial fattening, large numbers of animals are raised in large farms that are well managed in terms of feeding, breeding and disease control. Animals reared under the commercial fattening system are fed on good quality hay and high energy and protein concentrate diets. In Tanzania, this is mainly practiced in NARCO farms owned by the government (MLFD, 2009). According to Njombe and Msanga (2009) there are also few private feedlot operators which are involved in commercial feedlotting and these include Sumbawanga Agricultural and Animal Feeds Industries in Rukwa region, Manyara Ranch (Manyara region), Kisolanza Farm (Iringa region) and Mtibwa Feedlot in Morogoro region. The ever-increasing cost of feeds has contributed to production failures in most of these commercial fattening enterprises (MLFD, 2009). This is because feed is the major cost item among variable costs in a feedlot and accounts for over 70% of the production costs (Norris *et al*., 2002). This necessitates the research for alternative cheaper feed resources that can meet body requirements of beef cattle for production of good meat quality.

2.2 Feed Resources Used for Supplementation in Feedlots

Livestock feeds provide the basic nutrients including energy, proteins, minerals, vitamins and other micronutrients that are required by the animals for maintenance and production. Cereal grains and agro- industrial by-products are the main supplements used to provide energy to cattle under the feedlot system. Feeding rations with high-energy content improves beef cattle performance and reduces the time spent in the feedlot (Ramos *et al*., 1998; Cabrera *et al*., 2000; Weisberg *et al*., 2007). On the other hand, protein sources such as oil seed cakes provide protein for muscle growth or lean meat production. Cole and Hutcheson (1990**)** reported that increasing the crude protein (CP) concentration in the diets from 11 to 14% and energy from 10 to 12.5 ME MJ/kg DM, result in increased average daily gains of animals in the feedlot. Rutherglen (1995) recommended energy and protein contents of ME 10.93 to 11.21 MJ/kg DM and 12.31% to 15.91% CP, respectively, in cattle fattening diets. In the traditional beef production sector, this requirement is not met as most farmers rely only on grazing on poor natural pastures, and if animals are not supplemented, body requirements will not be adequately met. This result into poor performances of the animals being fattened (Aranda *et al*., 2001 and Nandonde, 2008).

Agro-industrial by-products such as oil seed cakes, cereal grains and molasses are well known conventional feed resources used for fattening cattle and their use result into better performance (Chamatata, 1995; McDonald *et al.,* 2002; Mawona, 2010). The use of cereal grains as human food and as the major ingredient in most of monogastric rations (Loerch, 1990; Laswai *et al*., 2002) creates competition, which lead to high demand and consequently, the price become high. Molasses has been reported to be used extensively in ruminants, both as a binder for compound feeds and source of additional energy to the diet (Weisbjerg *et al*., 2007). However, availability, storage and high transport costs are the major limitations of using molasses to fatten animals in most parts of Tanzania (Mwilawa, 2012).

2.3 Common Feed Ingredients Used in Traditional Feedlot and their Physical and Chemical Characteristics

Cotton seed hulls, rice polishing, and maize bran have been reported by various authors as alternative cheap sources of energy concentrates compared to cereal grains and molasses in cattle fattening. Likewise cotton seed cake and sunflower seed cake are cheap protein sources. The nutritive values of these feeds are indicated in Table 1 as reported by different authors. Despite their abundance, these feed resources have not been fully and optimally utilized as fattening rations in Tanzania (Nandonde, 2008; Mawona 2010; Malole, 2013). Hence, the need for more research to enable optimal utilisation of the locally available feed resources for production of quality beef.

2.3.1 Maize bran

Maize bran is a product of milling of dried maize grain and is composed of the bran coating (with high fibre) and few maize germ and starch particles. The nutritional quality of maize bran depends on efficiency of milling machines in removing the outer coating during flour processing. It is a good source of energy in ruminant and non ruminant rations (Dotto *et al*., 2004). Beef production studies have verified its potential for promoting increased weight gain when mixed with other ingredients (Weisbjerg *et al*.2007; Asizua *et al*. 2009). Major limitations could be the higher price due to competition and high demand as it is one of the most important ingredient in poultry and pig rations.

2.3.2 Rice polishing/bran

This is a by-product of rice milling and is among the cheapest ingredient for making ruminants and non-ruminant supplementary diets. Its quality depends on fibre level, but nutritionally is a good source of energy with moderate crude protein content. However, it can easily become rancid due to its high-unsaturated fat content (McDonald *et al*., 2002). Different studies have shown that rice polishing increases DM intake of steers when is used to supplement hay-based diets, green forage-based diets or sugarcane bagasse-basal diets (Toburan *et al*., 1990; Pal *et al*., 2004). Rice polishing with large proportion of broken rice and 12% oil have been shown to increase post-ruminal dietary protein and microbial nitrogen (Eliot *et al*., 1978). Similar observation has been reported by Creek and Squire (1976) and Lopez *et al*. (2005). However, cattle and finishing cows supplemented with rice polishing have lower performance compared to those supplemented with maize bran, soybean hulls or wheat bran (Osmari *et al*., 2008). Moreover, practical experience shows that inclusion of high levels of rice polishing in the diet reduces growth rate in cattle. This is probably due to high proportion of rice hulls in the mixture compared to bran and polishing (Gohl, 1982). Rice husks is the outer cover of paddy and is the most unsuitable for livestock feeding due to high fibre content with lignin and silica.

2.3.3 Cotton seed hulls

Cotton seed hulls are the outer coverings of cotton seeds, and the by-products of the dehulling step of cotton seed oil extraction. Cotton seed hulls are a fibrous product, primarily used to feed ruminants (Hall and Akinyode, 2000). They are sometimes mixed with cotton seed meals to create a higher density product that is easier to transport and handle (Blasi and Drouillard, 2002). Cotton seed hulls are one of the roughages that can be used to add bulk to diets rich in protein and energy, in order to reduce digestive upsets in ruminants. Due to their low density, it is difficult to transport them and their use is confined to a restricted market area (Blasi and Drouillard, 2002). Cotton seed hulls have been used in ruminant feeding in cotton growing areas including Tanzania (Chamatata, 1996; Mkonyi *et al*., 2006; Mlote *et al*., 2012). They are said to be palatable compared to other fibrous by-products and have a stimulatory effect on feed intake of diets with limited fibre content (Moore, *et al*. 1990). According to Chizzotti *et al*. (2005) cotton seed hulls could replace up to half of elephant grass silage (60% in the diet) in a complete diet for fattening steers, increasing the daily DM intake from 6.6 to 8.3 kg without altering DM digestibility. Chamatata (1996) observed increase in feed intake from 4.4 to 6.8 kg DM/d in cattle when cotton seed hulls replaced hay by 50%. A study by Markham *et al*. (2002) showed a decrease in average daily weight gain and increase in fat content in the carcasses of steers fed cotton seed hulls in replacement of alfalfa hay. This suggests that cotton seed hulls should be optimally combined with other ingredients to bear a desirable performance during fattening.

2.3.4 Cotton seed cake

Cotton seed cake is a by-product of oil extraction from cotton seeds. As a protein-rich feed, cotton seed cake is a common source of protein for ruminants and monogastrics. There is a wide range of cotton seed meals differing in protein, fibre and oil contents depending on the process of oil extraction (McDonald, *et al*. 2002). Different studies have shown that cotton seed cakes (dehulled and none dehulled) contain 25 to 50% CP, 5 - 10% fat, 5 - 25% CF.

In cattle diets, cotton seed cake can be safely included up to 15% (Weisbjerg *et al*., 2007) and it is a good protein supplement for low nutritive value forages and fibrous by-products because of its high protein content. The combination of cotton seed cake with a source of degradable energy increases the efficiency of its utilization and counteracts the effect of residual oil after extraction which depresses rumen microbes at high level Bonsi and Osuji (1997). Furthermore, cotton seed cake has a constipating effect on cattle, which is beneficial in feeds with high molasses content (Göhl, 1982). The main constraint for the use of cotton seed cake is the presence of gossypol, which limits its use in non-ruminant and young ruminant animals. However, studies have shown that cotton seed cake is a valuable cheap protein source for growing steers and bulls when used at recommended levels (Göhl, 1982). Table 1 indicates chemical composition of some common feedstuffs used in fattening cattle as reported by different authors.

Table 1: Chemical composition of some fattening feedstuffs

FEEDSTUFF	DM	CP	EE	CF	NDF	ADF	ASH	ME	AUTHOR
CSH	876.0	60.6	26.8	472.3	809.0	590.0	52.5	7.34	Mawona,(2010)
	926.0	88.5	42.0	408.0	624.0	463.0	41.7	-	Chamatata,(1996)
	937.0	79.1	30.8	-	655.0	437	32.0	-	Ramachandran, and Singhal (2008)
MB	880.0	120.0	35.0	-	260.0	-	46.0	11.0	Weisbjerg *et al*. (2007)
	894.6	106.4	61.2	757.0	-	-	61.8	-	Laswai *et al* .(2002)
	-	118.0	80.0	790.0	259.0	184.0	45.0	-	Dotto *et al*. (2004)
RP	921.0	116.0	21.8	279.0	-	-	68.0	-	Chamatata, (1996)
	920.0	130.0	17.0	151.0	256.0	122.0	105.0		Ambreen *et al*.(2006)
	-	144.0	14.9	137.2	-	-	81.0		Dotto *et al*. (2004)
	921.0	68.9	75.8	249.0	589.0	430.0	194.0		Mawona, (2010)
Molasses	730.0	55.0	4.0	-	0	-	140.0	9.8	Weisbjerg *et al.* (2007)
MM	897.8	111.8	35.0	24.7	-	-	15.5	-	Dotto *et al*.(2004)
	-	96.0	44.0	48.0	103.0	31.0	21.0	-	Laswai *et al*.(2002)
CSC	920.0	330.0	66.0	-	470.0	-	53.0	9.8	Weisbjerg *et al*. (2007)
	926.0	243.0	130.0	226.0	488.0	271.0	52.4	10.7	Mawona, (2010)
	-	349.0	75.0	166.0	405.0	329.0	66.0	-	Dotto *et al*. (2004)

CSH = Cotton seed hulls, MB = maize bran, RP = rice polishing, MM = maize meal, CSC = cottonseed cake, DM = dry matter, CP = crude protein, EE = ether extract, CF = Crude fibre, NDF = neutral detergent fibre, ADF = acid detergent fibre, ME = Metabolizable Energy in MJ/kg DM

2.4 Performance of Cattle in Fattening System

2.4.1 Feed intake

The amount and quality of feeds consumed directly influence the performance of animals in terms of live weight gain (Illius *et al*., 1998; McDonald *et al*., 2002). Different studies have shown varying intakes of fattened animals in terms of dry matter and, hence, different levels of performance. Mwilawa (2012) reported feed intake of 6.1 and 5.7 kg DM per day for Boran and TZSZ, respectively, fed hay and concentrate diet based on conventional feedstuff *adlibitum* feeding. This is contrary to the observation made by Meissner *et al*. (2006) who reported 8.5 kg DM intake for Holstein Friesian growing steers fed diets based on cereal by-product. Chamatata (1996) reported a feed intake of 6.282 kg DM/d of steers fed cotton seed hulls (50%) and hay and this is lower than the intake of 8.84 kg DM/d reported by Mawona (2010) for cattle fed cotton seed hulls based diets. The differences in intake may be caused by many factors. Emmans (1997) reported that, animals stop eating to limit metabolic or physical discomfort and energy requirement is considered to be the main intake driver. Similarly, McDonald *et al*. (2002) reported that intake is not only restricted by gut fill but also the animal's requirements. Fernandez-Rivera *et al*. (1994) reported that intake is dependent on animal body size, feed physical structure and fibre content, feed selectivity by free grazing animals and the way in which feed breaks down during digestion.

According to Mekasha *et al*. (2002) animals consuming poor-quality forage or feeds despite the high intakes, often fail to obtain sufficient nutrients from their diet to meet maintenance and production requirements. These variations in intakes provide evidence that optimal inclusion of particular ingredients should be established in order to optimize feed intake and thus maximize profit.

2.4.2 Feed efficiency and Growth performance

Feed efficiency in cattle fattening is described by feed conversion ratio, which is the amount of kg feed consumed divided by the kg of weight gained (McDonald *et al*., 2002). Growth performance is assessed by growth rate, which is the rate of increase in live weight and length at definite intervals of time (Berg and Butterfield, 1976). It is known that overall performances of livestock in the tropics are highly affected by feed quantity and quality (Buttery *et al*., 2005) which, in turn, influence feed utilization and body weight gain (Church, 1971, Stonaker, 1975; Preston and Leng, 1987). Under different tropical environments, reports indicate that beef cattle normally gain below 0.35 kg/d live weight (Chamatata, 1996; Mpairwe *et al*., 2003; Msanga and Bee, 2006) by grazing on poor natural pastures without supplementation. However, studies conducted to assess average daily weight gain under different levels of supplementation show varying daily gains ranging from 0.6 to 1.5 kg/d (Meissner *et al*., 1995; Chamatata, 1996; Asizua *et al*., 2009; Mawona, 2010; Mwilawa, 2012 Frylinck *et al*., 2013).

Supplementation with feedstuffs rich in nitrogen and readily fermentable carbohydrates improves the efficiency of feed utilisation through improving digestibility and degradation of fibre by rumen microbes (Khalili *et al*., 1993; Tolera and Sundstøl, 2000). The improved feed digestibility and rumen fermentation characteristics result in increased nutrient availability for tissue development in the animal, and hence, improved growth and meat yield. Therefore, supplementary diets need to be balanced to meet body nutrient requirements and more importantly CP and energy to enable better utilization and improved weight gain. Table 2 summarizes different feed efficiencies with corresponding growth performances to animals fattened under different feed formulations.

Table 2: Feed intake, efficiencies and growth performance in cattle fattening

Type of ingredients	FI kg DM/d	FCR	ADG kg/d	Researcher/author
MM(53%),molasses(11%),maize silage	-		1.00	Creek and Squire(1976)
Diet based agro-by-products	-		1.35	Meissner *et al*.(1995)
CSH (50%) + hay (50%)	6.28	10.3	0.612	Chamatata,(1996)
Commercial conc.	-		1.33	Frylink., *et al*.(2013)
Grazing +conc.	-		0.55	Asizua *et al*. (2009)
Maize stover +60% conc.	-		0.85	Asizua *et al*.(2009)
CSH and CSC +grazing		11.3	0.78	Mawona,(2010)
RP + grazing		18.8	0.44	Mawona,(2010)
Conc. (80%) +hay (20%)	5.0		0.81	Mwilawa,(2012)
Conc. (50%) + grazing	1.9conc.		0.63	Mwilawa,(2012)

ADG = average daily gain, MM = maize meal, CSH = cottonseed hulls, CSC = cotton seed cake, conc = concentrate, FI=feed intake, FCR = feed conversion ratio, DM = dry matter RP = rice polishing, kg = kilogram, d = day

2.5 Factors Affecting the Performance of Fattened Animals

Factors that are associated with animal, climatic conditions and feeds can influence the performance of fattening.

2.5.1 Animal factors

2.5.1.1 Age of animal

The efficiency with which a growing animal converts the food it eats into meat is determined primarily by the way in which it uses the digestible energy from its dietary intake. This digestible energy in feed consumed by animals is partitioned between heat production and gains in body tissues such as protein (i.e. meat) and fat. Importantly, as an animal matures, the ratio of fat to protein in body weight gains increases as it spends more energy to produce fats instead of protein and meat (Berg and Butterfield, 1976). In practical terms, this means that the efficiency with which it converts dietary energy into body tissues and live weight gains decreases. In most animals, the peak in efficiency for converting digestible energy into live weight gain has been found to occur at around 25 per cent of mature body weight. Schoonmaker *et al*. (2003) recommended crossbred bulls to be placed in fattening prior to 205 days of life to accelerate finishing with young, higher carcass weight, and marbled beef. Under traditional subsector in Tanzania, it has been shown that older cattle of over four years of age which are bought from livestock markets gain 0.64 kg/d under fattening condition (Mlote *et al*., 2012). This is lower compared to the on -station results of 0.889 kg/d reported by MLDF, 2009; Mwilawa, (2012) for fattened bulls with the age of 3 to 4 years. These findings indicate possibility of increasing feed efficiency and performance through fattening younger animals. This implies that, apart from feeding beef cattle well balanced diets to meet body requirements, age of animal can limit performance resulting into poor feed utilization.

2.5.1.2 Breed and sex

In cattle, as with other animals, the animal's sex and breed (Berg and Butterfield 1976; Cundiff *et al*., 2004) influence the efficiency of converting digestible energy into live weight gain. Females mature at lighter weights and tend to enter fattening phases (where increasing amounts of digestible energy are diverted into the production of fat), earlier than steers. Steers, on the other hand, enter fattening phases earlier than bulls. As a result, under conditions of normal or good nutrition, bulls will grow faster and more efficiently than steers and more efficiently than heifers (Berg and Butterfield, 1976). In addition to this, some breeds begin to fatten at lighter weights and others at heavier weights. These differences result in variations in the efficiency with which different breeds produce live weight gains. In a study to compare Ankole, Boran cattle breed and their crosses with Friesian, Asizua *et al*. (2009) obtained varying ADG where, Ankole x Friesian bulls were superior (0.62kg/d) to Ankole (0.56 kg/d) and Ankole x Boran crosses (0.50 kg/d) under the same fattening conditions. The study revealed that improved breeds and crossbreds gain weight faster than native animals. However, tropical breeds are more adapted to local climatic conditions, readily available, and can perform like other breeds under good management (MLFD, 2009, Mwilawa, 2012). Traditional fattening system in Tanzania is based on the most available indigenous beef cattle breeds (TZSZ and Ankole) which can still be improved using well balanced supplementary feeds to meet nutrient requirements using locally available feedstuffs (Nandonde, 2008).

2.5.2 Climatic conditions

In tropical countries, cattle performances are highly affected by environmental stresses, mainly heat stress, especially in areas where temperatures exceed the upper critical level (18 to 24°C). This reduces feed intake and therefore causing low rate of weight gain. Beef cattle make their best gains at temperatures below 25° C. In order to reduce heat stress and improve intake, several studies have suggested best and cheap ways of minimizing direct sun radiation and heat stress. Some of them include feeding fattening animals under shade, supply of cool and clean water and provision of supplementary ration during the early morning and late evening hours (Mader, 2003; Souza *et al*., 2010).

2.5.3 Feed factors and intake

Preston and Leng (1987) suggested ways to optimize the utilization of low quality feed resources and improve weight gain in beef cattle. Better utilization of low quality crop residues can be achieved by ensuring optimum conditions for microbial growth through supplementation of protein, energy, minerals and vitamins. Feed intake is maximized if the feed eaten provides all the nutrients required by the appropriate rumen microbes and by the tissues of the animal. Meisneer *et al*. (1995) found variation in weight gain among steers fed different dietary energy concentrations, but the same level of DM intakes. The result concurs with the observation made by DelCurto *et al*. (1990) who assessed two levels of supplementary protein with two levels of supplementary energy and found that responses in forage utilization were variable in growing beef steers. This implies that the level of energy and protein contained in the feeds for cattle fattening should be assessed and optimally balanced for better performance. The low digestibility of the fibre fraction is said to contribute to a general reduction in DM digestibility of high forage diets and, hence, limiting availability of nutrients to the animal.

A reduction of the poor digestible cell wall fraction is beneficial because it decreases rumen fill and increases DM digestibility. Studies have shown that feeds which have lower than 30 – 45% organic matter digestibility result into highly reduced intake (Owen, 1976; Kossilla, 1985). Lignin as part of plant fibre and indigestible fraction increases with plant maturity (Allen and Mertens, 1988) and has been shown to be the major limitation factor (Chamatata, 1996).

Mineral supplementation improves body metabolism and fattening performance. According to Underwood and Suttle (1999), about seven essential minerals (Na, K, Ca, Mg, P, S and Cl) are generally required in quite large amounts over 1g/kg DM of feed provided. These minerals can limit animal performance if their intake does not meet the requirements. Calcium and/or P as the most abundant in body metabolism, their deficiency or imbalance in feeds impairs bone mineralisation, especially in growing animals, but may also cause acute diseases. Phosphorus deficiency in cattle may deplete rumen microorganisms of P, which in turn impedes feed intake and DM digestibility, especially fibre digestibility (Ammerman *et al.*, 1971; Wilson and Kennedy1980; Ramirez- Perez *et al.*, 2009). In practical feeding, these minerals are available locally or in feed shops in forms of limestone, sodium chloride, and calcium or magnesium phosphate and are offered as mineral licks or as powdered ingredients which are included in concentrates. However, mineral blocks or mixed preparations are not widely used by many farmers and, hence, it is essential to include minerals in ration formulation to meet animal requirements. Table 3 summarizes recommended energy and protein requirements of cattle bulls under fattening.

Water is an essential nutrient for all animals. It is important for both animal welfare and good performance. For better growth performance beef cattle should have adequate supply of good quality water. The amount and quality of water required vary between stock size within the breed, and in response to the environmental conditions. According to Markwick (2007), finishing beef cattle require 35 to 80 litres of clean water per day.

Table 3: Energy (ME MJ/kg DM) and protein (MP g/d) requirements of feedlot bulls

Energy Value(ME)	Requirements	Live weight 100kg			Live weight 200kg			Live weight 300kg		
11 MJ/kg DM	DM intake kg/d	2.4	2.7	3.2	3.7	4.2	4.8	4.9	5.5	6.2
	Energy (MJ/d)	26	30	35	41	46	53	54	61	69
	Protein	249	328	402	288	360	429	324	392	456
	Target ADG (kg/d)	0.5	0.75	1.0	0.5	0.75	1.0	0.5	0.75	1.0
12 MJ/kg DM										
	DM intake kg/d	2.1	2.4	2.8	3.3	3.7	4.2	4.3	4.8	5.5
	Energy (MJ/d)	25	29	36	39	44	50	52	58	66
	Protein	249	328	402	288	360	429	324	392	452
	Target ADG (kg/d)	0.5	0.75	1.0	0.5	0.75	1.0	0.5	0.75	1.0
13 MJ/kg D										
	DM intake kg/d	1.9	2.1	2.4	2.9	3.3	3.7	3.9	4.3	4.8
	Energy (MJ/d)	24	28	32	38	43	48	50	56	63
	Protein	249	328	402	288	360	429	324	392	456
	Target ADG (kg/d)	0.5	0.75	1.0	0.5	0.75	1.0	0.5	0.75	1.0

Source: NRC, (2000)

2.6 Profitability of Cattle Fattening

Feedlot profit margin is a function of animal purchasing and selling prices, feed costs and utilization efficiency, and the time spent in the feedlot (Mkonyi, *et al*., 2006; Malope, *et al*., 2007; Mlote, *et al*., 2012). In Tanzania cattle buyers and fatteners become more active in buying and fattening cattle during the dry periods of the year when prices of feeds and cattle are low. The prices of fattened animals are estimated basing on body condition score, sex and body frame size of the animal. These tools are not reliable and transparent in determining profitability of fattened animals as they depend on buyers' experience. In a study to determine profitability of beef feedlotting, Malope *et al*. (2007) used average prices per unit live weights (kg) to establish the purchasing prices of fattened cattle. Depending on the available infrastructure, this could be the best option as the weights and prices of animals can be fore- determined prior and after fattening and reduce the chances of making loses.

Studies have shown that feed costs account up to 70% of total costs in cattle fattening (Norris *et al.*, 2002; Malope *et al*., 2007). This indicates the possibility of maximizing profit when the prices of feeds are low. Apart from low costs of feeds, feed utilization efficiency is also an important production parameter that can efficiently be used in beef cattle to maximize profit. It measures how much saleable product is being produced for each unit of feed consumed. Cattle that will convert feed into meat at a high rate (lower FCR) are highly desirable for feedlots.

Thus, identifying cattle which have lower intakes can optimize feedlot performance and is more valuable in environments that have low feed quality and/or quantity (Crews, 2005). Different studies have shown TZSZ to be one of the breeds that respond well at lower FCR (Malole, 2013), indicating the possibility of making profit.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Overview

The study was conducted in Kahama and Misungwi districts in Shinyanga and Mwanza regions, respectively. The districts were selected because there were many farmers who practice traditional cattle fattening during the dry season and the majority of them were using local available feeds for cattle fattening. This chapter describes a two-phase study, where phase one involved collection of information through focus group discussion with traditional cattle fatteners on the available and use of local feed resources in the respective districts. This was followed by an on-station feeding experiment aimed at comparing the performance and profitability of cattle fattening using formulated diets. The experiment was conducted at Tanzania Livestock Research Institute (TALIRI), Mabuki in Misungwi District.

3.2 Description of Study Areas

3.2.1 Kahama District

Kahama district is located 100 km South West of Shinyanga Municipal town at 3^0 15 to 4^0 30 S, and 31^0 00 to 33^0 00E. The district has average temperatures ranging from 20. 0^0 C to 26.0° C. Annual rainfall varies from 750 to 1030 millimetres. The District is located between 1050 and 1500 metre above sea level with a land area of 8477 km^2. Administratively, Kahama is divided into 5 divisions, 34 wards, and 211 villages.

3.2.2 Misungwi District

Misungwi district is about 46 km South East of Mwanza city and is located at $2^0 35^0$ to $3^0 15^0$S and $32^0 45^0$ to $33^0 15^0$E. Temperatures fluctuate from 28^0C to 30^0C and the average annual rainfall is between 600 and 800 millimetres. The District is located between 1000 and1500 metres above sea level and covers an area of 2553 km^2. TALIRI Mabuki is located in Misungwi district. It is one of the institutes under MLFD and it is where the on-station feeding experiment was done. This is because it has essential facilities and services that were important for this study including availability of cattle weighing scale, grazing area with watering facilities and other animal management tools.

Moreover, nearby farmers were organized and willing to provide the experimental animals. The predominant natural pasture species in the grazing area include *Hyperrhenia spp, Eragrostis spp* and *Bothriochloa spp*.

3.3 Study Design

3.3.1 Study 1: Collection of baseline information on feed resources used for cattle fattening

A total of 60 traditional cattle fatteners, 30 from each district were selected as respondents for the interview. The respondents were randomly sampled from a list of 250 farmers presented by heads of livestock Departments from the respective districts. A Checklist (Appendix 1) was used as a guideline for the discussions. Information on types of feed ingredients used for fattening, formulations, feeding methods and farmers' perceptions on profitability of cattle fattening was assessed.

3.3.2 Study II: Fattening experiment

Forty (40) Tanzania Shorthorn Zebu (TZSZ) bulls were randomly allocated to five dietary treatments in a completely randomized design in order to assess the effects of supplementing locally available feed resources. A total of five treatment diets were formulated as indicated in Table 4. Diet T_1 comprised maize meal (MM) and molasses as conventional ingredients and main sources of energy. Diets T_2, T_3, and T_4 were balanced rations formulated using maize bran (MB) and cotton seed hulls (CSH), CSH and rice polishing (RP) and CSH, MB, RP as major source of energy, respectively. The fifth treatment T_5 (the control diet) was formulated based on farmers' practice in the study area and comprised CSH and cotton seed cake (CSC). Diet T_1 is the best common conventional diet that has been proved to perform well in commercial cattle fattening (Mwilawa, 2012).

It was formulated to provide ME of 12.5 MJ/kg DM and 12.5 % CP that are recommended (NRC, 2000) for cattle fattening with expected average daily gain of 1.0 kg/day. Each treatment was assigned to a group of four animals and replicated two times, making a sample size of 8 animals per treatment and the total sample size of 40 animals.

The experimental bulls were grouped based on their similarities in initial body weights. The groups of the experimental bulls were later allocated randomly to the feeding pens. The amount of feeds provided was measured before feeding and the refusals were collected, and measured just before the next feeding. Feed intake and feed conversion ratio were computed for individual animals per pen (treatment).

Table 4: Feed ingredients of experimental diets

Ingredients	Treatment diets (%)				
	T_1	T_2	T_3	T_4	T_5
Maize meal	38	0	0	0	0
Cotton seed cake	13	15	15	15	15
Cotton seed hulls	-	37	37	30	83.5
Rice polishing	0	0	45	30	0
Maize bran	0	45	0	22	0
Molasses	47	0	0	0	0
Mineral mix	2	2	2	2	0
Salt	1	1	1	1	0
Urea	0.5	0	0	0	0
Local salt	0	0	0	0	1.5
Total	100	100	100	100	100

3.3.2.1 Source of experimental animals and their management

Farmers living nearby the experimental station bought the experimental animals (Sukuma strain of TZSZ bulls) from primary markets, mainly Misasi and Bungulwa in Misungwi district. The bulls were purchased under the supervision of the researcher in order to keep preliminary important records of age and purchasing prices. All animals had the age between 3 and 4 years (age was estimated by dentition method). The bulls were weighed and dewormed using NILZAN anthelmintic suspension and sprayed with acaricide (Dominex 50% EC) on arrival to control external parasites. Spraying was done on arrival, and then repeated twice in a week for the entire period of the feeding experiment. During the experiment, the bulls were penned in special pens (Plate 7) for supplementary feeding. Animals were provided with the treatment diets during the preliminary period for 10 days to familiarize them to the new diet and feed intake was adjusted before actual feeding trial and data collection started. During the last three days of preliminary period, all animals were weighed consecutively to obtain average initial weights. All animals were grazed during the day for six hours and supplemented with the experimental diets in the evening. All animals had free access to water.

3.3.2.2 Sources of feeds and feeding practices

The feed ingredients used to formulate the treatment diets (Plates1 to 6) were bought from milling machines, ginneries and animal feed shops in Mwanza and Shinyanga regions. Chemical composition values of the feedstuffs documented by Laswai *et al*. (2002) and Dotto *et al*. (2004) were used as basses in formulation of the treatments T_1, T_2, T_3 and T_4. The least cost feed formulation method using Excel 2007 software was used to determine dietary proportions (Table 4) of the feedstuffs required to obtain desired protein (12%) and energy (12.5 MJ ME / kg DM) levels that would meet the requirements of beef cattle. During daytime, the bulls were grazed on natural pastures in a 250 ha area from 0800hrs to 1400hrs and later supplemented *adlibitum* with respective allocated diets for each group (Plates 8 and 9) for 70 days after the days of preliminary period. Fresh feed offered was measured and refusals collected and measured. Both feed offered and refusals were sundried and weighed using weighing balance daily. All animals had access to clean water three times a day.

Plate 1: Molasses

Plate 2: Maize meal

Plate 3: Cotton seed cake

Plate 4: Rice polishing

Plate 5: Cotton seed hulls

Plate 6: Maize bran

Plate 7: Fattening pen at TALIRI – Mabuki (day 1)

Plate 8: Bulls feeding in pens

Plate 9: Bulls after 70 days of fattening

3.3.2.3 Determination of feed intake, feed conversion ratio and growth rate

The average feed intake (AFI) in kg DM per animal per day was calculated as the total amount of feed supplied in each pen minus the amount of feed refusals (kg) divided by four animals. The pasture DM intake was not computed due to complexity during the conduct of this experiment. Average feed conversion ratio (FCR) per animal in each treatment was calculated as feed DM intake per animal (kg) divided by weight gain (kg). Individual body weights of the experimental bulls were taken and recorded every week in the morning before feeding. Average daily gain (ADG) per animal was calculated as final weight minus initial weight in kg divide by 70 fattening days.

3.3.2.4 Determination of forage biomass on grazed pasture

The grazing area had a total area of 250 ha. To obtain the pasture biomass of the area, four arbitrary selected transect lines were used to demarcate representative sampling portions for collection of samples. The samples were collected after every 30 days during the trial. A metal quadrant of 0.75 m^2 was used to demarcate the sampling areas. Pastures within the quadrant were clipped at about 5 cm above the ground. Samples were collected from ten different places. An electronic (digital) weighing balance was used to weigh each sample immediately after clipping from each quadrant. The samples were then placed in clean pre-weighed empty paper bags. The samples were air dried to constant weight for ten days then reweighed. The average of air-dry samples was used to calculate the forage biomass of grazed area in kg DM/ha as;

$$\text{Forage mass kg DM/ha} = \frac{\textbf{Average dry weight (kg)x 10 000m}^2}{\textbf{0.75m}^2} \quad \text{.............(1)}$$

3.3.2.5 Determination of chemical composition of feeds

The feed ingredients, formulated treatment diets and natural pasture from grazing area were collected, stored and transported to the laboratory at the Department of Animal Science and Production, Sokoine University of Agriculture for chemical composition analysis. Dry matter, crude fibre, ash, crude protein and ether extract were analysed according to AOAC (2000). Dry matter (DM) content was determined by drying samples to constant weight in an oven at 105 ^{0}C for 24 hours. Ether Extract (EE) was determined using Soxtec extraction apparatus using petroleum ether at 50 to 60^{0}C. Ash was determined by incineration of samples in a muffle furnace at 550^{0}C for three hours. Crude protein (CP) was determined using Kjeldahl method. Nitrogen free extract was determined by subtracting percentages moisture, ether extract, crude protein, crude fibre and ash from 100. Neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL) were determined by using Ankom fibre analyzer according to Van Soest *et al*. (1991). *In Vitro* dry matter and organic matter digestibility were determined in accordance to Tilley and Terry (1963) procedures. Metabolizable energy of the diets was calculated according to MAFF (1975), i.e. ME (MJ/kg DM) = 0.012 CP + 0.031 EE + 0.005 CF + 0.014 NFE, where CP, EE, CF and NFE are in g / kg DM. The metabolizable energy of natural pasture in grazing areas was calculated according to McDonald *et al*. (2002) as ME (ME/kg DM) = 0.016OMD, where OMD = organic matter digestibility.

3.3.2.6 Assessment of body condition score

Body condition score (BCS) for each animal was observed progressively and recorded at the start, on fourth week and last week of feeding trial as recommended by Nicholson and Butterworth (1986). In this guide, the lowest score was one (highly emaciated) and the highest score was nine (very fat).

3.3.3 Gross margin analysis for fattened cattle

Gross margin (GM) analysis was used to determine the profitability or viability of fattening and was calculated as;

GM = GI – VC……………………………………..……....……………….(2)

Where;

GM =Gross Margin,

GI = Gross Income,

VC =Variable costs.

In calculating the Gross Income per head of bull, the following formula was used;

GI = Ps*(We) - Wb*(Pp)

Where; Wb = Average Live weight (LW) of bull at the beginning of fattening in kg

We = Average LW of the bull at the end of fattening in kg

Pp = Average purchase price for kg LW of a bull to be fattened in TZS

Ps = Average sale price for 1 kg LW of a bull at the end of fattening period in TZS

3.3.3.1 Purchasing costs of the experimental bulls

Because of market imperfections in livestock auctions such as buying animals in groups using average price per animal , and use of condition scores to estimate price of animals, each bull was valued per kg live body weight in order to have uniform pricing based on live weight (Malope *et al*., 2007).

The total purchasing cost was divided by the total body weights of bulls in order to establish the price of a kilogram live weight of the bulls. The purchasing price of each bull per treatment was, therefore, determined basing on established prices of kg live weights obtained from the existing market prices (Appendices 4 and 7).

3.3.3.2 Costs of experimental feeds

The costs per kg of the experimental diets (on DM basis) were determined basing on the prices of the included ingredients (Appendix 5). The total feed cost per bull in each treatment was determined by multiplying average cost of feed taken per bull per day to number of days of feeding experiment. The average cost of feed per kg live weight gain in each treatment was determined by dividing the average total feed consumed in 70 days by the bull to the change of weight.

3.3.3.3 Other variable costs

All other variable costs including casual labour, veterinary drugs, transport of feeds and animals and miscellaneous costs were summed up and averaged per individual experimental animal (Appendix 6). The total variable cost was, therefore, obtained by summing up costs of purchasing bulls, feed costs and other variable costs. The assumption was that most traditional fatteners graze their animals in communal grazing areas at zero cost; hence, no cost was included for grazing pasture.

3.3.3.4 Income from experimental bulls

The bulls were sold at livestock markets at the end of the feeding experiment. The total sales of the bulls were recorded and divided by their final total body weight to establish selling price per kg live weight. The value obtained was used to calculate selling price per animal in each treatment based on their body live weights (Appendix 7). This was done purposely in order to obtain selling prices based on live weight in each treatment. Total revenue was therefore obtained by summing up sales of each bull in each treatment. Currently, in Tanzanian livestock marketing systems, animals are bought and sold not based on their body weights. Furthermore, cattle buyers mostly buy animals in groups and use average prices to maximize profit. Under such situation, it was impossible to relate directly a particular bull to its actual selling price in each treatment. The Gross income was calculated as sales minus purchases.

3.4 Statistical Analysis

Study I

Descriptive statistics for the survey study were used to summarize the data and mean, standard error and percentage was computed using Statistical Package for Social Sciences (SPSS version 16) (SPSS for Windows, 2008).

Study II

Data generated on cattle fattening performance parameters (AFI, FCR, ADG and BCS) were analysed using GLM procedure of SAS (2003). The initial weights were treated as covariates. Least significance difference was used to determine the significance of the differences between means.

The model used was:

$Y_{ij} = \mu + T_i + b\,(X_{ij}\ \overline{X}) + e_{ij}$ ……………………..…..…………………….…………..(3)

Where;

Y_{ij} = response of the j^{th} animal from the i^{th} treatment

μ= Overall mean

T_i= effect of the ith treatment diet

b= regression coefficient of Yij on initial weight of bull

X_{ij}= initial body weight of an individual animal

$\overline{X}$ =Mean of initial body weight in the experiment

e_{ij}= random errors.

CHAPTER FOUR

4.0 RESULTS

4.1 General Overview

This chapter presents the results of this study. The focus group discussions with key informants revealed that most of the farmers who fatten cattle do not keep proper records on management and financial aspects of fattened animals. Hence, the information collected was based on the farmers' recall memory. Also the farmers did not have weighing scales for weighing feed ingredients used to formulate supplementary diets; instead they were using ungraduated buckets or other containers. To determine the amount of feed provided, each local container used by the farmers to measure the feed was filled with the respective feed and then weighed using a weighing scale during the interview. Determination of actual selling price of individual animals after fattening was not possible because of the practice of buying animals in groups in livestock markets. Livestock buyers use this system of averaging the prices depending on body condition scores of the animals. Therefore, in this study, the analysis of gross margin was based on the price per kg live weight instead of the price per animal.

4.2 Study 1: Feed Resources Used for Cattle Fattening

This section presents the results obtained through focus group discussions with key informants who practice traditional cattle fattening in the study areas and it was aimed at determining the feeding systems and major feed ingredients used to fatten cattle. Table 5 presents the most common locally available feeds and feeding practices used for cattle fattening by the respondents. It was found that cotton seed husks (CSH), rice polishing (RP), cotton seed cake (CSC) and maize bran (MB) were the most common local feed ingredients available and used to fatten cattle in the study area. Half of the respondents used CSH as the major ingredient in fattening. About 81.7% of the respondents mixed CSH with other ingredients to formulate the fattening rations. The majority (35%) of them mixed CSH and CSC and among these, 55% were mixing CSH and CSC at a ratio of 6:1 while some farmers used a ratio of either 5:1 (30%) or 10.1 (15%) for CSH:CSC. When asked about the criteria used to select the ingredients for fattening diets, some of the respondents (48.3%) said that they use ingredients that are easily available in their locality while others (23.3%) use ingredients which are most preferred by the animals and few farmers (10%) choose the ingredients that are cheap and easier to transport. With regard to feed formulation, 46% of the respondents learned from other cattle fatteners on how to formulate rations, 21.7% learned through seminars, 21% deduced themselves through trial and error and 10% learned from formal farmer field schools (FFS). The results in Table 5 indicate that 56.6 % of the respondents were providing supplementary diet in *adlib* amount to their animals being fattened and the supplementary diets were given after grazing. About 30% of the respondents provided restricted amount of supplementary diet after grazing, 11.7% of the farmers totally confined their animals and fed them *adlibitum* amount of concentrate (feedlotting) and very few respondents only grazed their animals without supplementation. When asked about the profitability of traditional fattening, 43.3% perceived fattening as a moderate profitable enterprise, 36.6% as good source of income, 6.7% as a very profitable source and 13.3% as an enterprise with low profit.

Table 5: Most common locally available feeds and feeding practices used for cattle fattening by the respondents in Misungwi and Kahama districts

Particulars	Misungwi	Kahama	Total respondents N=60 Total	%
Common available feed resources used				
Maize bran (MB)	3(10.0)	4(13.3)	7	11.7
Cotton seed cake (CSC)	7(23.3)	5(16.7)	12	20.0
Cotton seed hulls (CSH)	12(40.0)	12(40.0)	24	40.0
Sunflower seed cake	1(3.3)	3(10.0)	4	6.7
Rice polishing (RP)	6(20.0)	6(20.0)	12	20.0
Molasses	1(3.3)	0(0)	1	1.6
Common local feed formulations				
MB and CSH	3(10.0)	4(13.3)	7	11.7
CSH and RP	7(23.3)	6(20.0)	13	21.7
CSH only	7(23.3)	4(13.3)	11	18.3
CSH ,RP and CSC	2(6.7)	6(20.0)	8	13.3
CSH and CSC	11(36.7)	10(33.3)	21	35.0
CSH and CSC inclusion ratios in diet formulations				
CSH and CSC (5:1)	9(30.0)	9(30.0)	18	30.0
CSH and CSC (10:1)	7(23.3)	2(6.7)	9	15.0
CSH and CSC (6:1)	14(46.6)	19(63.3)	33	55.0
Factors determining the choice of ingredients				
Availability of the ingredient	13(43.3)	16(53.3)	29	48.3
Price of ingredient	7(23.3)	4(13.3)	11	18.3
Transport cost	4(13.3)	2(6.7)	6	10.0
animal preference	6(20.0)	8(26.7)	14	23.3
Source of knowledge for ration formulation				
Own initiative	7(23.3)	6(20.0	13	21.6
Learned from other farmers	16(53.3)	12(40.0)	2 8	46.7
Learned through seminars	5(16.7)	8(26.7)	13	21.7
Learned through farmer field school	2(6.7)	4(13.3)	6	10.0
Methods of fattening				
Total confinement (adlib feeding)	2(6.7)	5(16.7)	7	11.7
Grazing + confinement(*adlib* supplementary diet)	19(63.3)	15(50.0)	34	56.6
Grazing + confinement (restricted supplementary diet)	8(26.7)	10(33.3)	18	30
Grazing only	1(3.3)	0(0)	1	1.7
Profitability of feedlot enterprise				
Very profitable	2(6.7)	2(6.7)	4	6.7
Profitable	10(33.3)	12(40.0)	22	36.6
Fairly profitable	11(36.7)	15(50.0)	26	43.3
Not profitable	7(23.3)	1(3.3)	8	13.3

4.3 Study 2: Nutritive Value of Feeds and Performance of Fattened Bulls

4.3.1 Chemical composition of the local feed ingredients used for cattle fattening

The results for chemical composition of locally available feed ingredients are presented in Table 6. The CP content was highest in cotton seed cake; followed by maize bran, rice polishing and the lowest CP content was observed in cotton seed hulls. The EE was highest in maize bran and lowest in cotton seed hulls. The CF, ADF, NDF and ADL were highest in cotton seed hulls and lowest in maize bran. The ash content was highest in rice polishing compared to the other ingredients and was lowest in cotton seed hulls. Maize bran and rice polishing had higher NFE while cotton seed hulls and cotton seed cake had the lowest values. Maize meal had higher CP, EE, CF, NDF, ADF, ADF and NFE than molasses. It was found that the ash content was higher in molasses than in maize meal.

Table 6: Chemical composition of feed ingredients in g/kg DM

FEED INGREDIENTS	DM	CP	EE	CF	NDF	ADF	ADL	NFE	ASH
Cotton Seed hulls	963.1	70.5	40.8	536.7	814.0	622.5	107.1	32.4	31.6
Maize bran	932.8	117.1	120.4	60.6	427.8	69.6	1.0	71.3	42.0
Rice polishing	947.8	80.8	78.2	207.4	582.2	334.0	66.0	64.3	168.0
Cotton seed cake	959.9	320.1	67.4	206.5	498.8	257.7	64.7	36.6	67.3
Molasses	776.2	53.7	0.5	0	10.8	3.8	0	54.5	177.7
Maize meal	948.0	111.8	49.0	47.2	374.1	43.2	9.3	77.2	17.4

DM = Dry Matter, CP = Crude protein, EE = Ether extract, CF = Crude fibre, ADL = Acid detergent lignin, NFE = Nitrogen free extract, NDF = Neutral detergent fibre.

4.3.2 Nutritive value of the treatment diets and natural pastures grazed by the animals

The results in Table 7 present the chemical composition of experimental diets. The CP content varied among the diets and T_2 had the highest value, followed by T_1, T_4 and T_3 while T_5 had the lowest. It was revealed that T_2 had the highest EE whereas T_1 had the lowest value compared to the other diets. Diet T_5 had the highest CF and ADL compared to T_2, T_3 and T_4 while T_1 had the lowest value. Ash content was highest in T_3 whereas T_5 had the lowest value among the diets. The diet T_1 had the highest ME, followed by T_2, T_4 and T_3 whereas T_5 had the lowest. The *In vitro* dry matter digestibility (INVDMD) and organic matter digestibility (INVOMD) were higher in formulated diets T_1, T_2, T_4 and T_3 compared to T_5 which had the lowest values. Natural pastures from the area in which the animals were grazed had high DM and NDF and low CP content, INVDMD and INVOMD. The ME of pastures was also found to be low. The Forage biomass of grazing area was 1 331.1 kg DM/ha.

Table 7: Chemical composition (g/kg DM), energy (MJ/kg DM) content and digestibility (%) of experimental diets and natural pasture

CHEMICAL COMPOSITION	DM	CP	EE	ADF	NDF	ADL	CF	Ash	NFE	ME MJ/Kg DM	INVDMD %/ DM	INVOMD %DM
T_1	935.0	124.1	33.2	66.0	281.7	13.3	37.9	104.9	634.9	11.60	88.71	83.75
T_2	941.4	140.9	77	297.4	564.6	68.8	247.6	64.4	399.4	10.91	60.04	53.74
T_3	951.1	73.1	53.9	411.8	564.2	83.0	345.6	116.2	362.3	9.35	51.71	45.30
T_4	936.0	114.6	70.8	336.7	699.6	70.4	250.6	102.7	397.3	10.39	53.35	46.88
T_5	922.0	62.8	51.9	492.9	688.1	114.3	409.4	52.3	338.5	9.15	34.92	28.15
Natural pasture	926.0	62.1	17.2	343.0	688.1	37.0	290.9	84.5	-	6.08	42.52	38.00

DM = Dry matter, CP = Crude protein, EE = Ether extract, INVDMD = *In vitro* dry matter digestibility, INVOMD = *In vitro* organic matter digestibility, ADF = Acid detergent fibre, NDF = Neutral detergent fibre, CF = Crude fibre, NFE = Nitrogen Free Extract.

4.4 Effects of Diets on Performances of Fattened Bulls

Performance of fattened bulls was assessed in terms of feed intake, weight gain and daily weight gain. The effects of dietary treatments on feed intake (FI), body weight gain and average daily weight gain (ADG), feed conversion ratio (FCR) and body condition score (BCS) and the analysis of variance are presented in Table 8 and Appendix 2, respectively.

4.4.1 Average daily feed intake

The analysis of variance indicated significant ($P \leq 0.05$) differences among the experimental diets with respect to feed intake. The results show that animals on T_5 had the highest (5.58 kg DM/d) average feed intake per animal while those on T_2 had the lowest (4.07 kg DM/d) intake compared to those on the other diets. However, the feed intake of animals fed T_2 was not significantly different ($P > 0.05$) from that of animals given T_4 diet.

Table 8: Effects of treatment diets on performance of the experimental bulls

Parameter	Treatment Diets						
	T1	T2	T3	T4	T5	SEM	P-value
Number of animals	8	8	8	8	8		
Average Initial body weight (kg)	184.09^{a}	164.41^{b}	156.66^{b}	165.46^{b}	192.36^{a}	6.11	0.0009
Average final body weight (kg)	234.7^{a}	233.0^{a}	215.4^{b}	231.3^{a}	213.9^{b}	3.00	0.0005
Average feed intake (kg DM/d)	4.45^{c}	4.07^{d}	4.74^{b}	4.16^{d}	5.58^{a}	0.04	0.0001
Weight gain (kg)	62.08^{a}	60.44^{a}	42.85^{b}	58.69^{a}	41.35^{b}	3.00	0.0001
Average daily gain kg/d	0.90^{a}	0.86^{a}	0.61^{b}	0.83^{a}	0.58^{b}	0.04	0.0001
Feed conversion ratio	5.11^{c}	4.76^{c}	7.73^{b}	5.05^{c}	10.27^{a}	0.50	0.0001
Average Initial body condition score	2.4	2.3	2.3	2.4	2.8	0.00	0.2875
Average Final body condition score	8.18^{a}	7.80^{ab}	7.09^{bc}	7.92^{a}	6.64^{c}	0.30	0.0012

Means within the same row with different superscript letters are significantly different at $P < 0.05$, SEM = standard error of the mean, kg = kilogram, DM = dry matter, d = day

4.4.2 Body weight gain and average daily weight gain

The experimental diets had different influence on body weight gain of fattened bulls. The bulls fed diets T_1, T_2 and T_4 had significantly ($P \leq 0.05$) higher body weight gain compared to those on diet T_3 and the control diet T_5. Similar results were observed on growth rate which showed that animals offered T_1, T_2 and T_4 diets had significantly ($P \leq 0.05$) higher ADG compared to those offered T_3 and T_5. The highest (0.90 kg/d) ADG was observed on the bulls offered diet T_1, but their ADG was not significantly different ($P > 0.05$) from that of animals fed T_2 and T_4 diets. The ADG of animals fed the control diet T_5 was the lowest (0.58 kg/d), but it was not significantly different ($P > 0.05$) from those offered T_3.

4.4.3 Feed conversion ratio

The FCR varied among the treatment diets. The highest (10.27) FCR (the poorest feed utilization) was found in animals fed diet T_5 and differed significantly ($P \leq 0.05$) from the FCR of the animals fed other diets. Moreover, the results show that diets T_1, T_2 and T_4 were better in terms of utilization ($P \leq 0.05$) compared to T_3. Diet T_2 had lowest (4.07) FCR i.e. was the most efficiently utilized compared to the other diets.

4.4.4 Body condition score

The results indicate that there were significant differences ($P \leq 0.05$) in final BCS among the animals under different treatments. Bulls fed diets T_1, T_2 and T_4 had higher ($P \leq 0.05$) BCS than those on diets T_3 and T_5. Animals on diet T_1 had highest (8.18) final BCS whereas those on T_5 had the lowest (6.64).

4.5 Gross Margin Analysis of Fattened Bulls

Table 10 presents the economic evaluation (incomes, variable costs and gross margins) of fattened bulls for each treatment. The prices per kg live weight of the experimental bulls before and after fattening were TZS 1290.29 and 1917.39, respectively. In this study the diet T_1 had higher ($P \leq 0.05$) feed cost compared to the other diets. The feed cost for diet T_3 was lower ($P \leq 0.05$) compared to that of the other diets. Other variable costs apart from feed costs were constant for all treatments; hence, the total variable cost followed the same trend as that of feed costs.

The bulls offered diets T_1, T_2 and T_4 had higher ($P \leq 0.05$) gross income compared to those offered T_3 and T_5. The gross margin was significantly higher ($P \leq 0.05$) for the animals offered diet T_4 than of those in the rest of the treatments. The gross margins for the animals fed diets T_2, T_3 and T_5 were not different ($P > 0.05$) from each other. The gross margin for the bulls offered diet T_1 was lower ($P \leq 0.05$) than that of animals in the other treatments.

The cost of feed per kg weight gain for the bulls offered diet T_1 was the highest (3340 TZS) and differed significantly ($P \leq 0.05$) from that of the animals offered other diets. It was observed that animals offered diet T_4 had the lowest cost of feed per kg weight gain (1340 TZS) and differed significantly ($P \leq 0.05$) from that of the animals offered the control diet T_5, but did not differ ($P > 0.05$) from that of the animals fed diets T_3 and T_2 The results for Analysis of variance for gross margin of fattened bulls are presented in Appendix 3.

Table 9: Average gross income, variable costs, gross margins and cost of feed per kg gain of the experimental bull ('000 Tanzanian shillings)

Parameters		Treatments						
		T1	T2	T3	T4	T5	SEM	p-value
1. Revenue	Sales of fattened bulls	470.90[a]	431.89[b]	384.05[c]	430.46[b]	446.19[ab]	12.36	0.0005
2. Variable costs								
	Purchase of bulls	242.31[a]	216.39[b]	206.20[b]	217.78[b]	253.19[a]	7.88	0.0009
	Feed costs	230.78[a]	111.04[b]	78.16[e]	88.88[d]	103.04[c]	2.43	0.0001
	[1]Others costs	61.25	61.25	61.25	61.25	61.25	0.00	-
	Total costs	292.03[a]	172.29[b]	139.27[e]	150.14[d]	164.29[c]	2.43	0.0001
3. Gross income	Sales-purchases(bulls)	233.36[a]	219.76[a]	181.91[b]	216.97[a]	197.98[b]	6.27	0.0001
4. Gross Margins								
	Over feeds	2.59[c]	108.72[b]	103.90[b]	128.08[a]	94.94[b]	5.88	0.0001
	Over all variable costs	-58.66[c]	47.47[b]	42.65[b]	66.83[a]	33.90[b]	5.88	0.0001
4. Cost of feed/ kg gain		3.34[a]	1.61[c]	1.59[c]	1.34[c]	2.37[b]	0.14	0.0001

Means within the same row with different superscript letters are significantly different at $P < 0.05$, SEM = standard error of the mean.
[1]Other costs = Veterinary drugs, transportation of feeds and Animals, permits and feeds packing materials

CHAPTER FIVE

5.0 Discussion

5.1 Local Feed Resources and Feeding Practices Used in Traditional Cattle Fattening

Results of the present study revealed that cotton seed hulls, rice polishing, maize bran and cotton seed cake are the major feed ingredients used in traditional cattle feedlot system of the study areas. This observation agrees with the findings of previous studies (Mkonyi *et al*., 2006; Mwaona, 2010 and Mlote *et al*., 2012) in similar agricultural production systems. The higher utilization of cotton seed hulls and cotton seed cake compared to the other feed ingredients observed amongst the traditional cattle fatteners is probably because of their abundant availability and low level of utilization by other livestock species, particularly mono-gastric animals. Furthermore, CSH are highly palatable to cattle and can be mixed with unpalatable ruminant feeds to increase feed intake (Chamatata, 1996). This could probably be the major reason for using CSH as the main ingredient in formulating local fattening diets.

The lack of common standard ration or commercial diets for cattle fattening in Tanzania has forced farmers to use locally available feed ingredients and mixing them in different ratios during feed formulation depending on individual's experiences. Some farmers got the knowledge for formulating fattening diets by learning from their neighbours. Malole (2013) also reported the lack standard ration for cattle fattening and that feed formulation among farmers in traditional fattening sector differs from one individual to another. This has resulted into farmers having fattened animals with different body condition score and variation in meat quality.

The majority of the farmers were also feeding their animals *adlibitum* amount of supplementary diets after grazing. This was probably intended to improve performance through increased intake. Despite such attempt, the majority of them were not satisfied with the performance of fattened animals and profitability of cattle fattening enterprise. This might be due to excessive use of low quality feed materials and unbalanced diets which caused poor growth performance of fattened animals. Moreover, *adlibitum* feeding of animals in the traditional sector creates additional unnecessary feeding costs. In recent years, the demand for local feed ingredients has increased tremendously (Mlote *et al*., 2012) due to increase in cattle fattening practices in the study areas. This indicates the need of training the farmers on feed formulation and proper planning for optimal utilization of these locally available feed materials. The use of well balanced diets could improve the performance of fattened animals and maximize profit margin in traditional cattle fattening system.

5.2 Nutritive Value of the Feed Ingredients and Experimental Diets

5.2.1 Chemical composition of locally available feed resources

Cotton seed hulls were the most commonly used ingredient for cattle fattening in the study areas, but had the lowest CP content compared to the other locally available feed ingredients (i.e. maize bran, rice polishing and cotton seed cake). The CP value of cotton seed hulls observed in this study is slightly lower than that reported by Chamatata (1996) (88.5 g/kg DM) and Ramachandran and Singhal (2008) (79.1 g/kg

DM), but higher than the CP content (60.6 g/kg DM) that was reported by Mawona (2010). The difference is probably due to the differences in location where the CSH were sourced and efficiency in cotton seed dehulling process. Other authors (Garleb *et al*., 1988 and Ramachandran and Singhal (2008) also have reported the high CF, NDF and ADL values in CSH. The low CP and high CF content in CSH is a characteristic of roughage feeds and hence its use as the sole diet could decrease performance of fattened animals. However, CSH are highly palatable (Chamatata, 1996) to ruminant animals, hence, can be mixed with unpalatable ruminant feeds to increase feed intake. This is probably the reason that makes some cattle fatteners to use it for fattening animals without mixing with other ingredients. The major limitations of CSH are the high CF content and bulkiness. The CF contains indigestible lignin (Garleb *et al*., 1991), thus necessitates optimization of its inclusion level in diets in order to achieve higher performance of fattened animals. On the other hand, the bulkiness of CSH increases transportation costs from one place to another. This implies that cattle fattening should be done near the source of CSH in order to reduce the fattening costs.

Maize bran as an energy source in fattening diets was used by few farmers and the results for chemical composition indicate that the CP content observed in the present study is higher than the CP of 109 g/kg DM reported by Mlay *et al*. (2006), but lower than the CP content of 126.5 g/kg DM reported by Kavana and Msangi (2005). The EE and NDF percentages are higher than that reported by Weisbjerg *et al*. (2007) while the ADF and ash contents are lower than that reported by Dotto *et al*. (2004). The variation observed in chemical composition of maize bran is due to difference in soil fertility, maize variety, milling machine and also climatic conditions of the study areas. Maize bran as a by-product from maize processing is cheap and good source of energy, but its availability depends on status of maize production.

Rice polishing which is a by-product of rice milling, was found to contain moderate CP and high CF, but the values observed in this study are lower than those reported by Chamatata (1996) and higher than those observed by Mawona (2010). The NDF value in the present study is higher than that reported by Ambreem *et al*. (2006) and lower than 335 g/kg DM reported by Mlay *et al*. (2006). The variations in chemical compositions, especially with respect to CF are probably a result of differences in milling machine efficiencies to clearly separate rice bran from rice husks. The major limitation for the use of rice polishing is that it can easily become rancid if stored for a long time because of its high content of unsaturated fats (Kunkle *et al*., 2001). Furthermore, rice polishing leads to diarrhoea if included at high level in the diets.

The chemical composition of CSC obtained in this study is similar to that reported by other workers (Dotto *et al*., 2004; Weisbjerg *et al*., 2007). Cotton seed cake had higher CP content compared to the other ingredients, thus it can be used as plant protein source in fattening rations. Moreover, it is palatable and among the least expensive sources of protein in many regions of the developing world (Göhl, 1982; McDonald *et al*., 2002). Molasses was found to contain very low CP and negligible amount of EE, CF and ADL, but had high NFE and ash content. The chemical composition of molasses in the present study is similar to that reported by Weisbjerg *et al.* (2007). The values of CP, EE and CF in maize meal in this study were higher than those observed by Laswai *et al*. (2002). The differences are probably the result of different soil characteristics, storage conditions and plant varieties.

5.2.2 Nutritive value of treatment diets and natural pasture grazed by fattened animals

Among the experimental diets, T_2 had the highest CP content and this could be attributed to inclusion of CSC and MB that contained higher CP relative to the other ingredients. The observed CP values for diets T_2, T_1 and T_4 are within the range of 11 and 14% reported by Cole and Hutcheson (1990**)** as suitable for fattening diets**.** This implies that the formulated diets T_1, T_2 and T_4 are more suitable for supplementation of finishing cattle. According to Rutherlgen (1995) the CP content in the diet should be between 12.31 and 15.91% to meet protein requirement of fattened cattle and promote high growth rate. The CP content of natural pasture observed in this study was below 7% and is similar to that reported by Chamatata (1996). This finding indicates that, the natural pasture available in grazing areas are of poor quality and alone cannot meet the recommended CP requirements for higher performance of beef cattle (Msanga and Bee, 2006). Thus, there is a need to supplement grazing animals with concentrates containing high protein content.

The results for chemical analysis show that diets T_2 and T_4 had higher EE compared to the other diets. This might be due to high level of MB included in these diets since MB had higher EE content relative to the other ingredients. The EE contents for the diets T_2, T_3 and T_4 are higher than the maximum recommended level of 6% for matured cattle diets (Parish and Rhinehart, 2008). Despite this high EE level, there were no negative effects such as diarrhoea observed on the animals fed these diets.

The observed higher level of CF and ADL in diet T_5 might be due to high inclusion level of CSH which contained high proportions of those components. The percentages of CF and ADL were slight less in diets T_2, T_3 and T_4 because these diets had low level of CSH. Diet T_3 had relative higher CF and ADL compared to T_2 and T_4 and this is attributed to inclusion of high amount of RP which contained larger proportions of CF and ADL. The CF in diet T_1 was below the minimum recommended level of 170 g/kg DM in concentrates for supplementation of beef cattle (NRC, 2000). The CF in diets T_2, T_3, T_4 and T_5 exceeded the minimum required level. Although T_2 and T_4 had high CF content, they are more suitable than T_3 and T_5 due to relatively higher levels of CP and ME which is enough to meet the body requirement for microbial activity needed to ferment low quality forage (Preston and Leng, 1987; Toleraa and Sundstøl, 2000).

The energy (ME) value was highest in the diet T_1 and lowest in T_5. The energy contents in T_1, T_2 and T_4 are within the range of 10 to 13 MJ/kg DM recommended by Rutherlgen (1995) and NRC (2000) for beef cattle. This implies that these diets have adequate energy content and can be used for fattening of cattle. In this study, the IVOMD was higher in diets T_1, T_2 and T_4. The IVOMD values for these diets are higher than the minimum level of organic matter digestibility (45%) recommended by Kossilla (1985) for beef cattle feeds. This is probably due to higher and balanced CP and ME levels in these diets. This is supported by McDonald *et al*. (2002) who said that optimal protein and energy levels in the diet ensure optimum conditions required for microbial growth to promote digestibility of organic matter in the rumen. Based on the higher digestibility values obtained in the current study for diets T_1, T_2, T_3 and T_4 it can be said that these diets are more suitable for fattening of cattle compared to the diet T_5 which is the farmers' feeding practice.

5.3 Performances of Fattened Animals

5.3.1 Feed intake

The results indicate variations in average daily feed intake among bulls supplemented with the different diets. The feed intake of animals on T_1 is within the range reported by other authors for molasses and maize based diets (Creeek and Squire 1976; Mwilawa, 2012). The concentrate intakes for the bulls offered diets T_2, T_3, T_4 and T_5 that contained CSH are less than the intake of 8.84 and 6.28 kg DM/d reported by Chamatata (1996) and Mawona (2010), respectively, for steers fed diets formulated based on cotton seed hulls. The differences in feed intake is attributed to differences in animal body weights and feed formulations that were used in the two experiments. The higher feed intake observed in animals fed diet T_5 compared to the intakes of those offered diets T_1, T_2, T_3 and T_4 is due to the fact that the diet T_5 contained only CSH as the source of energy and thus the bulls on this diet ate more in order to compensate for the low energy density of CSH and meet body requirements (Emmans, 1997; McDonald *et al*., 2002). Furthermore, T_5 had higher inclusion level of CSH which is very palatable and have high passage rate (Morales *et al*., 1989; Moore *et al*., 1990). This contributed to high intake observed in this study. This is contrary to the notion that the high fibre feedstuffs like CSH depress intake as they take up space and limit the capacity of the rumen (Mertens, 1992 and McDonald *et al*., 2002). In this study, the addition of CSH to the supplementary diets increased feed intake. The CP and energy contents of diets T_1, T_2, and T_4 were in the range recommended by NRC (2000) and thus could support microbial activity for increased intake of poor roughage. According to Rowe *et al*. (1991) when animals feeding on low quality roughage are supplemented with diets containing adequate amount of nutrients such as CP and ME, the intake of the basal diet is increased. This concurs with earlier observation made by DelCurto *et al*. (1990) in a study on utilization of dormant low quality tall grass. The authors found that feeding beef cattle a supplementary diet containing sufficient crude protein increased both intake and utilization of the low-quality forage. In this study it was observed that the overall DM intake (from grazing and concentrate supplementation) was higher for animals offered diets with higher CP and ME contents (i.e. T_I,T_2, and T_4) indicating these diets are suitable for fattening cattle compared to T_5.

5.3.2 Body weight gain and average daily weight gain

All animals increased in body weight, which implies that, TZSZ bulls have ability to gain weight when supplemented. The higher body weight gain which was noted in bulls fed diets $T_{1,}$ T_2 andT_4 compared to that of animals fed the other diets might be due to the sufficient nutrients contained in these diets which were able to meet body requirements. The growth rate of bulls in this study was higher than the growth rate of 0.35 kg/d reported by Mpairwe *et al*. (2003) and Msanga and Bee (2006) for bulls grazing on natural pasture without supplementation. The growth rate of bulls fed diet T_1 is higher than the ADG of 0.812 kg/d observed by Mwilawa (2012) for TZSZ bulls fed molasses based concentrate and hay under total confinement. The slightly higher ADG might be the result of free choice and selectivity of quality natural pasture during grazing (Wilson and Kennedy, 1980). The growth rate of animals under T_1 is lower than the ADG of 1.13 kg/d observed by Luziga (2005) in Boran crosses supplemented with molasses based concentrate. This difference in ADG is possibly due to breed difference (Asizua *et al*., 2009).

The growth rates of animals fed diet T_2 and T_4 in the current study are higher than the ADG of 0.612 and 0.78 kg/d observed by Chamatata (1996) and Mawona (2010), respectively, on TZSZ cattle supplemented with CSH and CSC. This might be attributed to proper nutrient balance in the experimental diets used in this study. However, the daily weight gains observed in bulls fed diets T_2, T_3, T_4 and T_5 in this experiment are lower than the values of 1.0 to 1.5 kg/d reported by Mkonyi *et al*. (2006) in TZSZ supplemented with concentrate diet formulated using CSH in Mwanza region. This might be due to breed difference and different ratios of the concentrate ingredients and quality of basal feed (pasture) in the study areas.

The weight gain of the bulls fed the control diet T_5 was lower than that of those offered the formulated diets T_1,T_2, T_3 and T_4 because the control diet comprised of CSH as the only energy source but had high fibre content and low ME, CP and digestibity. Thus, animals supplemented with the control diet were not able to meet their nutritional requirement for growth. This implies that CSH cannot be used as the sole source of energy in fattening diet. Feeds with high protein and energy contents are required in order to promote rumen microbial growth and, hence, improve digestibility of the poor quality roughage (Weisbjerg *et al*. 2007). The higher weight gain and growth rate values observed in animals fed T_1, T_2, and T_4 implies that locally available feeds can promote higher growth performance in beef cattle if the diet is properly formulated to meet the nutritional requirements.

5.3.3 Feed conversion ratio

The observed lower utilization efficiency (high FCR) for treatment diet T_5 might be due to low organic matter digestibility compared to that of formulated diets T_1, T_2, T_3 and T_4. The same reason could be attributed to the higher FCR observed in animals fed diet T_3 which contained 37% CSH. The substitution of MB with RP might have lowered the digestibility, hence low utilization by animals on T_3. The reason for the lower digestibility might be the high CF and ADL contents contributed by higher inclusion levels of RP in T_3 and CSH in T_5. These findings are similar to those reported by Gadberry *et al*. (2007) who found low organic matter digestibility and poor feed utilization efficiency and performance of finishing cows fed rice by-product based diets compared to those fed maize bran. According to Allen and Mertens (1988) and McDonald *et al*. (2002) high level of CF and ADL in ruminant rations negatively affect the organic matter digestibility and thus, end up with poor extraction of the required nutrients (Preston and Leng, 1987; Sanon *et al*., 2007). The implication of poor feed utilization is the increased costs of feeding whereby more feed is required to produce a unit weight gain or meat. In order to improve feed utilization, it is recommended to include not more than 30 to 50% of

CSH in beef rations (Torrent *et al*., 1994; Garleb *et al*., 1988; Chamatata, 1996). Basing on the results of the present study, it can be said that the proportions of ingredients used in diets T_1, T_2, and T_4 were optimal for promoting high weight gain and animals fed these diets had better feed utilization compared to those fed diet T_3 and the control diet T_5.

5.3.4 Body condition score

The higher BCS for bulls fed diets T_1, T_2 and T_4 could be attributed to the high weight gain which is the result of animals eating good quality diets. These diets ($T_{1,}$ T_2 and $T_{4)}$ contained adequate nutrients which were readily available to the animals to meet their body requirements compared to diets T_3 and T_5. Body condition score showed a positive relationship with weight gain of the experimental bulls. The findings in the present study are consistent with the findings by Bartholomew *et al*. (2003) who found a positive linear association in unit change of body condition with weight change for oxen fed diets of different qualities. This implies that the condition score of beef cattle can be manipulated depending on the type of diet used. Basing on the results of this study it can be said that the formulated diets T_1, T_2 and T_4 had optimal energy and protein contents and animals fed these diets showed better BCS compared to those on diets T_3 and T_5.

5.3.5 Gross margin analysis

The observed higher feed cost of diet T_1 can be attributed to the high costs of the ingredients that were used in feed formulation. Molasses as a by-product of sugarcane processing, is abundantly available near sugar processing industries but is not easily available in many parts of Tanzania located far away from sugarcane industries, and this triggers high transportation cost. The use of maize meal in the diets for fattening cattle is not feasible because of the competition of its use for human food and monogastric animal feeds.

In the current study it was found that the use of locally available feed ingredients (CSH, RP, and MB) reduced feed costs from 79% (T_1) to 56% (T_3) of the total costs. This decrease in feed cost resulting from the use of locally available and cheap feed resources is similar to the decline of 70% in feed costs reported by Norris *et al.* (2002). This implies that the use of CSH, RP, and MB in cattle fattening supplementary diets can reduce cost and increase profit margin of feedlot operations. Animals supplemented with diet T_4 had the lowest cost of feed per body weight gain. This shows that diet T_4 is a cheap feed, but has high nutritive value and can be used as a fattening feed to produce a unit weight of meat at a relatively lower cost compared to the other diets. Although animals provided with the diets T_1 and T_2 had higher total weight gain and ADG than the animals fed other diets, the cost of feed consumed per kg live weight gain was also higher for these diets. Diet T_3 had the lowest cost, but higher FCR and higher feed intake which resulted into the animals fed this feed to have lower gross margin than diet T_4. This means that cheap diets should also be of good quality in order to be efficiently utilized by the animal and meet body requirements for weight gain and, hence, high selling price margin and gross margin. Therefore, this study has revealed that farmers can adopt the use of CSH, RP, and MB as sources of energy and CSC as a source of protein in cattle finishing diets and their proportions in the diet should be like those in diet $T_{4.}$

CHAPTER SIX

6.0 Conclusion and Recommendations

6.1 Conclusions

Based on the findings obtained in the present study, the following conclusions were made.

i. The main feed resources used by farmers to fatten cattle are cotton seed hulls, rice polishing, maize bran and cotton seed cake.

ii. Supplementation of animals with diet based on maize meal and molasses results into higher body weight gain, average daily weight gain and body condition score. But the feed cost was high and thus the use of this diet was uneconomical.

iii. Animals supplemented with diet T_2 had better feed utilization compared to the other diets.

iv. Fattening of animals with diet T_4 resulted into higher gross margin (profit) compared to the other diets. Hence, diet T_4 is more profitable than diets T_1, T_2, T_3 and T_5.

6.2 Recommendations

Further research is required to determine the qualities of meat produced from animals supplemented with different levels of CSH, RP, MB, and CSC. Further research is also needed to test the performance of diet T_4 under farmer's management conditions.

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APPENDICES

Appendix 1: Discussion checklist with farmer's key informants

1. What are the major feed resources available in your area and are normally used to supplement cattle during fattening?
2. How do you use the available feed resources during fattening? Do you use them individually or in combination and how?
3. In that combination you use, what are common mixing ratios?
4. What is the reason of using such mixing ratio?
5. How did you come to know the feed formulation you are using?
6. How do you feed your animals during fattening?
7. Are you satisfied with profitability in using such feed formulations?

Appendix 2: Analysis of variance for performance parameters

Dependent Variable: Final body weight

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	4	3254.625531	813.656383	12.61	<.0001
IBWT	1	9437.277171	9437.277171	146.24	<.0001

R-Square	Coeff Var	Root MSE	Mean
0.892292	3.559683	8.033314	225.6750

Dependent Variable: Final body condition score

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	4	12.86280559	3.21570140	5.74	0.0012
IBWT	1	0.33495471	0.33495471	0.60	0.4446

R-Square	Coeff Var	Root MSE	Mean
0.404533	9.944616	0.748332	7.525000

Dependent Variable: Weight change

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	3369.734342	673.946868	10.48	<.0001
Error	34	2187.269658	64.331461		
Corrected Total	39	5557.004000			

R-Square	Coeff Var	Root MSE	Mean
0.606394	15.11057	8.020690	53.08000

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	4	3256.671364	814.167841	12.66	<.0001
IBWT	1	26.630342	26.630342	0.41	0.5243

Dependent Variable: Average daily gain

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	0.72380164	0.14476033	10.36	<.0001
Error	34	0.47519836	0.01397642		
Corrected Total	39	1.19900000			

R-Square	Coeff Var	Root MSE	Mean
0.603671	15.65853	0.118222	0.755000

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	4	0.69998907	0.17499727	12.52	<.0001
IBWT	1	0.00480164	0.00480164	0.34	0.5617

Dependent Variable: Average Feed intake

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	16.29465137	3.25893027	320.85	<.0001
Error	34	0.34534863	0.01015731		
Corrected Total	39	16.64000000			

R-Square	Coeff Var	Root MSE	Mean
0.979246	2.190946	0.100783	4.600000

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	4	9.83783664	2.45945916	242.14	<.0001
IBWT	1	0.81465137	0.81465137	80.20	<.0001

Dependent Variable: Average feed conversion ratio

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	199.1238290	39.8247658	19.66	<.0001
Error	34	68.8739210	2.0257036		
Corrected Total	39	267.9977500			

R-Square	Coeff Var	Root MSE	Mean
0.743006	21.62206	1.423272	6.582500

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	4	167.4629239	41.8657310	20.67	<.0001
IBWT	1	1.9323290	1.9323290	0.95	0.3356

Appendix 3: Analysis of Variance for economic evaluation of bull fattening

Dependent Variable: Average purchasing price of bull

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treat	4	11918267904	2979566976	5.99	0.0009
Error	35	17408275946	497379313		
Corrected Total	39	29326543850			

R-Square	Coeff Var	Root MSE	Mean
0.406399	10.01442	22302.00	222699.0

Dependent Variable: Average Selling Price of bull

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	4	32106437789	8026609447	6.57	0.0005
Error	35	42741811854	1221194624		
Corrected Total	39	74848249644			

R-Square	Coeff Var	Root MSE	Mean
0.428954	8.076226	34945.60	432697.1

Dependent Variable: Average Gross Income

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	4	12984745978	3246186495	10.31	<.0001
Error	35	11015301830	314722909		
Corrected Total	39	24000047808			

R-Square	Coeff Var	Root MSE	Mean
0.541030	8.447882	17740.43	209998.6

Dependent Variable: Average Feed Cost

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	4	122737589248	30684397312	650.38	<.0001
Error	35	1651272704	47179220.114		
Corrected Total	39	124388861952			

R-Square	Coeff Var	Root MSE	Mean
0.986725	5.613895	6868.713	122352.0

Dependent Variable: Average total variable cost

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	4	122737589248	30684397312	650.38	<.0001
Error	35	1651272704	47179220.114		
Corrected Total	39	124388861952			

R-Square	Coeff Var	Root MSE	Mean
0.986725	3.741088	6868.713	183602.0

Dependent Variable: Average gross margin over feed

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	4	77051305802	19262826451	69.52	<.0001
Error	35	9697790038	277079715		
Corrected Total	39	86749095840			

R-Square	Coeff Var	Root MSE	Mean
0.888209	18.99186	16645.71	87646.58

Dependent Variable: Average overall gross margin

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	4	77051305802	19262826451	69.52	<.0001
Error	35	9697790038	277079715		
Corrected Total	39	86749095840			

R-Square	Coeff Var	Root MSE	Mean
0.888209	63.06012	16645.71	26396.58

Dependent Variable: Average cost of feed per unit gain

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	4	21267236.35	5316809.09	34.12	<.0001
Error	35	5453971.63	155827.76		
Corrected Total	39	26721207.98			

R-Square	Coeff Var	Root MSE	Mean
0.795894	19.25165	394.7503	2050.475

Appendix 4: Purchasing and selling prices of experimental bulls in livestock markets based on body condition (Tanzanian shillings)

S/NO	Purchasing price/bull	Selling price/bull	S/NO	Purchasing price/bull	Selling price/bull
1	195000	420000	21	240000	400000
2	220000	510000	22	270000	410000
3	195000	430000	23	215000	380000
4	230000	480000	24	230000	410000
5	260000	460000	25	220000	410000
6	250000	480000	26	185000	420000
7	270000	460000	27	160000	440000
8	280000	520000	28	185000	520000
9	200000	390000	29	220000	465500
10	215000	410000	30	270000	380000
11	200000	370000	31	270000	520000
12	190000	430000	32	220000	380000
13	235000	490000	33	220000	380000
14	220000	390000	34	260000	430000
15	245000	490000	35	180000	430000
16	240000	520000	36	220000	380000
17	153500	330000	37	270000	450000
18	180000	330000	38	240000	450000
19	160000	360000	39	240000	475500
20	184500	350000	40	270000	560000

Appendix 5: Ingredients and treatment diets costs in Tanzanian shillings

Ingredient	T 1			T2			T3			T4			T5		
	Inclus. %	ingr. cost/ kg	Diet cost/ kg	Inclus. %	ingr cost/ kg	Diet cost/ kg	Inclus. %	ingr cost/ kg	diet cost/ kg	Inclus. %	ingr cost/ kg	Diet cost/kg	Inclus. %	Ingr cost/ kg	diet cost/ kg
Maize Meal	38	680	258.4	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
Cotton SC	13	300	39	15	300.00	45.00	15	300.00	45.00	15	300.00	45.00	15	300.00	45.00
Molasses	47	650	305.5	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
Cotton SH	0	0	0	37	200.00	74.00	37	200.00	74.00	30	200.00	60.00	83.5	200.00	167.00
Maize bran	0	0	0	45	400.00	180.00	0	0.00	0.00	22	400.00	88.00	0	0.00	0.00
Rice Polishing	0	0	0	0	0.00	0.00	45	100.00	45.00	30	100.00	30.00	0	0.00	0.00
Mineral mix	1	2000	20	2	2000.00	40.00	2	2000.00	40.00	2	2000.00	40.00	0	0.00	0.00
Salt	0.5	800	4	1	800.00	8.00	1	800.00	8.00	1	800.00	8.00	0	0.00	0.00
Urea	0.5	1500	7.5	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
Local salt	0	0	0	0	0	0.00	0	0.00	0.00	0	0.00	0.00	1.5	800.00	12.00
Total	100		634.4	100		347.00	100		212.0	100		271.00	100		224.00

Inclus. = Inclusion, ingr. = Ingredient, kg = kilogram.

Appendix 6: Other variable costs

ACTIVITY/ITEM	COST /40 BULLS (TZS)	AV COST /BULL (TZS)
Drugs	200 000.00	5 000.00
Labour	900 000.00	22 500.00
Transportation of animals	800 000.00	20 000.00
Transportation of feeds	250 000.00	6 250.00
Movement permit	100 000.00	2 500.00
Miscelaneous	100 000.00	2 500.00
Parking Materials(bags)	100 000.00	2 500.00
	2 450 000.00	61 250.00

Appendix 7: Purchasing and selling prices of bulls based on kg live weight in Tanzanian shillings

S/NO	Treatment	BULL NO	Purchasing price (TZS/kg live weight)	Initial Weight (kg)	Purchasing price (TZS/animal)	Selling price (TZS/kg live weight)	Final bodyweight (kg)	Selling price (TZS/animal)
1	TI	243	1290.29	169.00	218059	1917.39	226.70	434660
2	TI	246	1290.29	163.75	211285	1917.39	236.36	453182
3	TI	203	1290.29	171.63	221446	1917.39	238.25	456806
4	TI	206	1290.29	179.50	231607	1917.39	234.57	449759
5	TI	247	1290.29	187.38	241768	1917.39	247.59	474724
6	TI	227	1290.29	203.13	262090	1917.39	272.06	521632
7	TI	231	1290.29	203.13	262090	1917.39	251.79	482777
8	TI	204	1290.29	195.25	251929	1917.39	257.46	493648
9	T2	218	1290.29	153.25	197737	1917.39	214.73	411709
10	T2	223	1290.29	153.25	197737	1917.39	218.72	419359
11	T2	215	1290.29	153.25	197737	1917.39	214.83	411910
12	T2	229	1290.29	145.38	187576	1917.39	202.44	388154
13	T2	225	1290.29	174.25	224833	1917.39	243.29	466469
14	T2	242	1290.29	171.63	221446	1917.39	236.57	453585
15	T2	201	1290.29	174.25	224833	1917.39	232.58	445934
16	T2	220	1290.29	190.00	245155	1917.39	238.88	458014
17	T3	224	1290.29	137.50	177415	1917.39	180.18	345473
18	T3	202	1290.29	140.13	180802	1917.39	187.32	359163
19	T3	221	1290.29	141.18	182157	1917.39	196.35	376477

S/NO	Treatment	BULL NO	Purchasing price(TZS/kg live weight)	Initial Weight (kg)	Purchasing price (TZS/animal)	Selling price(TZS/kg live weight)	Final bodyweight (kg)	Selling price(TZS/animal)
20	T3	236	1290.29	145.38	187576	1917.39	190.16	364599
21	T3	219	1290.29	176.88	228220	1917.39	212.73	407884
22	T3	214	1290.29	182.13	234994	1917.39	218.51	418957
23	T3	233	1290.29	161.13	207898	1917.39	206.64	396207
24	T3	234	1290.29	169.00	218059	1917.39	210.53	403656
25	T4	241	1290.29	159.03	205188	1917.39	208.11	399026
26	T4	210	1290.29	148.00	190963	1917.39	205.17	393389
27	T4	222	1290.29	142.75	184189	1917.39	213.78	409897
28	T4	216	1290.29	153.25	197737	1917.39	208.64	400032
29	T4	212	1290.29	176.88	228220	1917.39	241.92	463852
30	T4	208	1290.29	174.25	224833	1917.39	222.81	427211
31	T4	213	1290.29	190.00	245155	1917.39	248.12	475730
32	T4	239	1290.29	179.50	231607	1917.39	247.49	474522
33	T5	250	1290.29	179.50	231607	1917.39	210.53	403656
34	T5	209	1290.29	180.03	232284	1917.39	207.38	397616
35	T5	249	1290.29	169.00	218059	1917.39	211.58	405669
36	T5	207	1290.29	171.63	221446	1917.39	215.99	414125
37	T5	205	1290.29	203.13	262090	1917.39	233.42	447545
38	T5	217	1290.29	203.13	262090	1917.39	242.03	464054
39	T5	211	1290.29	205.75	265477	1917.39	261.98	502305
40	T5	245	1290.29	226.75	292573	1917.39	278.78	534517