CHARACTERISTICS, FEEDING AND MARKETING PRACTICES OF THE EMERGING PERI-URBAN CAMEL PRODUCTION SYSTEM IN ISIOLO COUNTY, KENYA

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A thesis submitted to the Graduate School in fulfilment of the requirements for award of the Doctor of Philosophy Degree in Animal Science of Egerton University

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DECLARATION AND RECOMMENDATION

DECLARATION

I declare that this thesis is my original work and has not been previously presented in this or any other University known to me for the award of any degree.

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RECOMMENDATION

This Thesis has been submitted with our approval as University supervisors.

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DEDICATION

I dedicate this thesis to my two dear wives, Suldan Sheikh Muktar and Hawa Abdullahi Adan; and our children, Ismail, Ibrahim, Yakub, Yussuf, Abdihakim, Fatuma, Abdimasoud, Hanan and Hashim.

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ABSTRACT

Pastoral camel management strategies in northern Kenya, characterised by free herd mobility that enables efficient utilisation of rangeland resources, is slowly but progressively adopting restricted camel foraging within the vicinity of urban milk market outlets as seen in Isiolo town. The emerging peri-urban camel production system (PUCPS) has potential livelihood benefits to households but there are emerging pressures that can impede its sustained development and benefits. Key emerging pressures are on forage feed resources and market oriented milk production. This study explored options for improving feeding and marketing practices in PUCPS, guided by four research questions. The questions were: what are the key defining characteristics of PUCPS; what are its drivers for development; what are the challenges to its development; and what are the interventions to support its sustained development? Data were obtained from cross sectional surveys, focus group discussions, laboratory analyses of camel forages and supplementary feeding trials. Descriptive and inferential statistics comparing pastoral and peri-urban camel systems in Isiolo County indicated that camels remain the primary source of livelihoods even as pastoralists' transition to semi-sedentary urban lifestyle and milk is the key product. The drivers behind the emergence of PUCPS in Isiolo were: progressive sedentarization of pastoral communities with strong tradition for consumption of camel milk, a niche urban market for camel milk in Nairobi, and reliable (tarmac) road to urban markets. Compared to pastoral, peri-urban systems exhibited greater market orientation with large volumes of marketed milk, 2.4 times more sale of steer surplus stock (25.8 vs 62.8%) and purchase of 2.2 times more heifer breeding stock (12.3 vs 27.5%). The growth of Isiolo PUCPS has been rapid but is sensitive to disruption of peace and stability, market barriers due to poor milk hygiene practices and vulnerability to trypanosomosis and haemorrhagic septicaemia disease incidences that cause economic losses. Seasonal fluctuations in forage nutritive values were marked, being superior during wet season than in dry season (mean CP 15.70% vs 9.86%; mean CF 23.22% vs 32.57%; mean NDF 44.38% vs 53.15%). Consequently, wet season milk off-take declined by 33% during dry season and by 55% during severe drought which substantially reduced milk volume sold by 36% during dry season and by 60% during severe drought. Supplementary feeding with maize germ-based diet significantly ($p<0.001$) improved milk yield of lactating camels by 26% over acacia pods-based diet and by 50% over rangeland foraging and browsing. Major challenges to the continued development of Isiolo PUCPS are reported and the relevant interventions proposed. It is concluded that camel production in peri-urban areas near towns like Isiolo is gaining significance as an economic activity due to commercialization of camel milk.

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LIST OF ABREVIATIONS AND ACRONYMS

ADF	Acid Detergent Fibre
ANOVA	Analysis of variance
AOAC	Association of Official Analytical Chemists
ASALs	Arid and Semi-Arid Lands
CAHWs	Community Animal Health Workers
CBOs	Community Based Organizations
CF	Crude Fibre
CP	Crude Protein
DM	Dry Matter
KSh.	Kenya shillings
LSD	Least Significance Difference
NDF	Neutral Detergent Fibre
NGOs	Non-Governmental Organizations
PUMCMS	Peri-Urban Marketed Camel Milk System
SAS	Statistical Analysis System

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Introduction

Camel is an important livelihood asset in the arid and semi-arid lands (ASALs) of Kenya, which cover over 83% of the land mass and supports about 30% (12 million) of the country's population. Camels are the source of food, cash income, transport means and have significant cultural functions to pastoral communities dominating in the ASALs (Guliye et al., 2007; MoLD, 2007; Mehari et al., 2007a and 2007b; Mahmoud, 2010). These pastoral communities keep the one humped camels (*Camelus dromedarius*) which is estimated at 2.97 million (KNBS, 2010), mainly concentrated in the ASALs of Kenya. The camels in Kenya have the potential to produce 350 million litres of milk annually and 10,000 tonnes of meat a year (Faye, 2007).

In arid northern Kenya, camel production has traditionally been under pastoral production systems (Kaufmann, 1998), where animals are owned individually and grazed in communally owned rangelands. Pastoral production systems are subsistence oriented characterised by low inputs and outputs, seasonal mobility in search of pastures, water, mineral licks and to escape from ethnic resource-based conflicts. Free herd mobility utilising extensive rangeland grazing resources is considered more suitable form of utilising the ASALs (Sombroek et al., 1982; Behnke and Scoones, 1993; Kaufmann, 1998). This mobility of the herds that has enabled pastoralists to utilise extensive rangeland resources more efficiently (Farah et al., 2004a; Guliye et al., 2007) is now progressively adopting restricted grazing around peri-urban areas within the vicinity of urban market outlets for milk and camel stock.

Isiolo town in northern Kenya has a camel production that exemplifies this emerging peri-urban camel production system (PUCPS) with the potential of adding value to camel milk and stock which would improve livelihoods of the pastoral communities (LPP, LIFE Network, IUCN-WISP and FAO, 2010) in the ASALs. However, the increased concentration of camel herds within the peri-urban area is putting pressure on forage feed resources for camels which gets severe in dry seasons. Field (1995) reported seasonal variations of forage species, observing that trees, shrubs and dwarf shrubs dominate camel diets in wet season while the proportion of trees and shrubs decline during the dry seasons when leaves are shed off. This seasonality of forage species has implications on the sustainability of PUCPS that is emerging in Isiolo town. The orientation towards marketed milk production demands for changes in herd management practices in response to market requirements. However, changing management practices responsive to market requirements could be challenging to pastoralists especially milk hygiene and disease control practices. There is the need therefore for empirical evidence to objectively inform development agencies interested in supporting the development of the emerging PUCPS in arid northern Kenya to sustain the livelihood benefits to pastoral households.

1.2 Statement of the problem

Isiolo town in northern Kenya has an emerging peri-urban camel production system (PUCPS) characterized by restricted camel foraging within the vicinity of urban milk market outlets. However, the practice of restricting camel foraging within the vicinity of urban milk market outlets introduces pressure on forage feed resources which worsens during dry and drought seasons that are frequent in the ASALs and practices responsive to market demands. These calls for adjusting herd management practices to respond to pressures on forage feed resources and market responsiveness. The build up of these pressures and failure in adjusted management practices can impede development of the emerging peri-urban camel systems and diminish its livelihood benefits to pastoral households, yet there is limited understanding of the underlying situation and intervention options to support the development of the system. Feed supplementation is an intervention option, but a viable strategy may be a challenge designing while improved herd management practices responsive to market demands may be unattainable under ASALs circumstances though remains prerequisite to sustaining better market access.

1.3 Objectives

1.3.1 Overall objective

The overall objective of this study was to assess the characteristics, feeding and marketing practices of the emerging peri-urban camel production system around Isiolo town in Northern Kenya, in order to identify constraints and intervention options to support the development of the system.

1.3.2 Specific objectives

The specific objectives were to:

(i) Establish the key characteristics defining the emerging peri-urban camel production system in Isiolo County, Kenya.

(ii) Assess the extent of market integration in the live camels and camel milk trade.

(iii) Evaluate the nutritive values of forages that camels commonly browse within Isiolo peri-urban area rangelands.

(iv) Evaluate the effects of dry season feed supplementation on performance of lactating camels browsing rangeland forages.

1.4 Research questions

(i). What are the key characteristics defining the emerging peri-urban camel production system in Isiolo County, Kenya?

(ii). To what extent are camel keepers involved in trading of live camels and camel milk?

(iii). What is the extent of seasonal variation in the nutritive values of camel forages in Isiolo peri-urban area?

(iv). To what extent can supplementary feeding improve milk yield, milk composition and body weight of lactating camels during dry season?

1.5 Justification

Adequate understanding of the characteristics of the emerging peri-urban camel production system coupled with integration of camel production into the market economy would be useful in planning and implementation of targeted camel development programmes so as to continue its livelihood benefits to pastoral households. In addition, knowledge of the quality of forages commonly browsed by camels in peri-urban areas would improve our understanding of the prevailing status of camel feeding, particularly the extent of nutritional constraints, while supplementary feeding intervention can sustain milk productivity to enhance food and income security to peri-urban camel owners.

1.6 Expected outputs

(i). Characteristics of the evolving peri-urban marketed camel milk system defined.

(ii). Challenges in market oriented management practices in peri-urban camel milk system identified.

(iii). The most common forage plants for camels identified.

(iv). Extent of seasonal variation in nutritive values of camel forages determined.

(v). Supplementary feeding intervention for the dry season feeding formulated and validated.

(vi). PhD Thesis for award of a doctoral degree.

(vii). Scientific papers presented in conferences and published in refereed journals.

1.7 Outline of the thesis

Chapter one of this thesis is a general introduction contextualising the situation followed with chapter two on extensive literature review emphasizing on the objectives of the study. The next chapters present findings on characteristics of the emerging system in chapter three, extent of market oriented herd management practices in chapter four and the extent of nutritional seasonality of feed resources in chapter five. The effects of supplementary feeding are presented in chapter six. All the findings are then integrated in a general discussion to answer the four research questions that guided the study to identify the key characteristics of the emerging system, the drivers for its development, challenges to its development and the interventions to support its sustained development.

1.8 Definition of Terms

Arid and Semi Arid Lands: Areas where rainfall is low and usually insufficient for sustained agriculture, but adequate for pastoralism.

***Forra* (Somali/Boran)**: Mobile herds or flocks of mostly non-lactating females and male animals.

Husbandry: Caring for animals.

Nomadic: Wandering without any fixed base.

Pastoralism/Pastoralists: The production systems and the people who practice them in which 50% or more of the gross household income is derived from livestock or livestock related activities.

Pastoral camel system: This refers to camel production system away urban settlements. It serves subsistence roles and has minimal market integration and access to amenities such as veterinary and extension services. The herds are usually larger and more mobile in the vast rangelands in search of pasture, water, mineral licks and security from ethnic resource-based conflicts.

Peri-urban camel system: This refers to rearing of camels, particularly milking herds, within the vicinity of urban market outlets for camel products. In Isiolo peri-urban area there is a thriving market for camel milk, meat and live animals. Herds are smaller, less mobile and there is access to modern amenities.

Rangeland: A large open area of grazing and browsing.

Subsistence: Basic needs to keep oneself alive.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of camel production

The one-humped dromedary camel (*Camelus dromedarius*) is an important livestock specie uniquely adapted to hot arid environment (Yagil, 1985; Schwartz, 1992a; Wilson, 1998). This unique adaptability makes it ideal for exploitation in many pastoral systems in the arid and semi-arid areas of Africa. The world camel population is estimated at 19 million, with the vast majority of these (about 15 million) being found in Africa and 4 million in Asia (Farah et al., 2007; Guliye et al., 2007). Of this estimated world population, 17 million are believed to be one-humped dromedary camels (*Camelus dromedarius*) and 2 million two-humped Bactrian camels (*Camelus bactrianus*) (Farah et al., 2007). Somalia (with over 6 million camels) has the largest camel population in the world, perhaps representing one-third of all dromedary camels (Wilson, 1998; Farah et al., 2007). They are found mainly in arid and semi-arid areas where the average rainfall is less than 350 mm per year. The four neighbouring countries – Somalia, Sudan, Ethiopia and Kenya – have a combined camel population comprising 99% of the camels in the Greater Horn of Africa (GHOA), 97% of all camels in Africa and 75% of all camels in the world (Field, 2005). North African countries (Morocco, Libya, Tunisia, Algeria, Mauritania, Niger, Mali) also have camels although in varying numbers. In Asia, camels are mainly found in the middle-eastern countries of Saudi Arabia, Jordan, Syria, UAE, Iraq, Yemen, Oman, Lebanon, and also India and Pakistan.

Kenya has only one-humped (dromedary) camels, which is an important component of the livestock sector in the arid and semi-arid lands (ASALs) of northern Kenya where 66% of the population live below the poverty line (ADF, 2003). In the past, because of lack of regular census, Kenya's camel population was estimated at below the one million mark. However, according to the results of 2009 livestock census, the national camel population is estimated at 2.97 million (KNBS, 2010) and the provincial breakdown is presented in Table 2.1. Schwartz and Dioli (1992) estimated that camels constitute 6% of Kenya's national domestic herbivore biomass (DHB), but 25% of the DHB in the ASALs. In the traditional pastoral production systems, livestock rarely serve a single purpose. It is common to rear livestock for multiple uses. Thus, the dromedary camel is a multipurpose animal primarily kept for milk and meat production as well as transportation. It is also a financial reserve (asset) and security (against drought related losses) for pastoralists and plays an important role in social status and wealth (Woubit et al., 2001; Guliye et al., 2007). For example, customarily, camels are the most important indicator of wealth and a determinant of status within the Somali society (Mahmoud, 2010). Camel milk has played an important role in the nutrition of the population in arid zones of East African countries. The milk is traditionally consumed either fresh or in the form of fermented milk, known as "*Sussa*", among the Somali pastoralists where it contributes up to 30% of the annual caloric intake (Farah et al., 2007). There also exists an export trade of male camels for slaughter in the Middle East countries (Wilson, 1998; Farah, 2004a; Mahmoud, 2010).

Table 2.1: Camel population by province in Kenya.

Province	Population	Percentage
North Eastern	1,700,893	57.25
Rift Valley	968,192	32.59
Eastern	248,634	8.37
Coast	51,045	1.72
Western	2,037	0.07
Central	321	0.00
Nyanza	59	0.00
Nairobi	20	0.00
Total	2,971,111	100.00

Source: KNBS (2010)

Camels in Kenya are mainly kept by the Somali people in north eastern province of Kenya (Table 2.1), where much of the larger breeds and herds are found. The camels later spread to the Gabbra and Rendille tribesmen of Marsabit County. In recent years, camels have gained significant importance and are increasingly breaking the cultural barriers in its adoption by tribes that hitherto did not keep them (Field, 1995; Guliye et al., 2007). Consequently, camels are slowly increasing in numbers, replacing the traditionally kept cattle, among the Samburu, Maasai, Turkana and Pokot tribes. The threats posed by recurrent prolonged drought spells in ASAL areas have certainly awakened its inhabitants to pay more attention to camel keeping.

2.2 Camel production systems

2.2.1 Pastoral production systems

Production systems involving camels have traditionally been very extensive and highly mobile. Consequently, nomadism, far from being an inefficient land use system, is a sophisticated response to the use of resources that are temporally and spatially highly variable in quantity and quality (Wilson, 1998). Pastoral resource use pattern is predicated upon risk spreading and highly flexible mechanisms such as mobility, communal land ownership (a prerequisite for mobility and, therefore nomadism), large herd sizes that are diversified, and herd separation and splitting (Farah, 1996a). Camel producers in northern Kenya adopt herd splitting as a risk spreading strategy. They split their herds into home-based herds (usually lactating) and nomadic herds (mostly dry) (Noor, 1999; Farah et al., 2004a). Nomadic camels are normally moved and cover long distances looking for browse forages.

Pastoral camel production systems are principally subsistence oriented. The traditional product is milk which is mainly consumed in the family. Where the situation allows there is some sale of milk to purchase cereals and other basic foodstuffs. Data on camel milk production performances under pastoral systems are presented in section 2.3 below. In most pastoral societies slaughter for meat is rare except for a few old and barren animals (Wilson, 1998), and during ceremonies (Guliye et al., 2007). Where milk is the main production objective males may be sold for slaughter and there is thus a prevalence of females in the herd. However, where the transport role is important, more males are kept and there will be as many males as females in the herd (Wilson, 1998).

The usual habitat of the camel is characterized by high temperatures and scarcity of water. As a consequence of these environmental conditions, these areas are also characterised by considerable seasonal variations in available forage quantity and quality (Schwartz, 1992a). However, proper husbandry and sound management techniques are the reasons for the success of camel pastoralists in an environment characterized by erratic rainfall and frequent droughts (Farah et al., 2004a).

2.2.2 Peri-urban production systems

Camel production systems have not remained isolated from the pressures of the twentieth century. Consequently, camel systems are undergoing adaptive changes and transformations associated with emerging demographic, political, environmental and socio-economic factors (Hashi et al., 1995; Wilson, 1998; Farah et al., 2004a). Herders are becoming more and more attached to semi-permanent settlements. The resulting short-range management system differs from the traditional long-range mobility patterns, which is used to balance the feed budgets of the herds (Hashi et al., 1995). The emergence of peri-urban camel production systems are encouraged by increased commercialization of camel milk resulting from increased demands by urban populations, more reliable and permanent water supplies and improved veterinary services, and opening up of export and local markets (Wilson, 1998). Mohammad (1991) reported that camel pastoralists are becoming less nomadic and milk production for marketing purposes is gaining importance. Consequently, in Africa, peri-urban camel dairying is now practiced in Djibouti, Mauritania, Morocco, Somalia and Sudan (Hashi et al., 1995; Wilson, 1998).

In northern Kenya, highly attractive prices and other strong incentives are attracting more and more pastoralists into the market economy (Farah et al., 2004a). Urban market demand for camel products is also expanding in major Kenyan cities, particularly Nairobi (Guliye et al., 2007), where many communities of pastoral background have migrated in search of business and employment opportunities (Simpkin et al., 1996). Many nomads now wish for themselves or their children the benefits provided by urban cities, including medical services and education (Yagil, 1994; Wilson, 1998).

Minimal data is presently available for milk production performance under peri-urban systems. In Mauritania, where camel milk constitutes a major component of peri-urban milk production around the capital city of Nouakchott, well managed camels produce as much as 8 – 10 litres per day at the peak of lactation, over a lactation period of about 12 months (Wilson, 1998).

The transition from a highly mobile to a more sedentary system can have several challenges. These include feeding, livestock and livestock products marketing, and diseases and veterinary care. According to Wilson (1998), peri-urban systems are transitional in that they will not be sustainable in the long term as urban populations increase and environmental concerns become more important. Consequently, the same author envisions that peri-urban systems will probably gradually be displaced to more and more distant suburbs and eventually return to rural areas; though their management will benefit from techniques, such as milking practices, feeding systems and general management, learnt in the peri-urban systems. Increase in environmental degradation, as a result of loss of adaptive management practices and the breakdown of traditional social regulating mechanisms, are some of the negative effects of the system (Farah, 1996a; Wilson, 1998). Some potential positive effects that may improve both profitability and sustainability of the production system are opportunities for improved land management, investment in land improvement and forage production, and the use of new technologies.

2.3 Major camel products

2.3.1 Camel meat

The most serious problem in assessing meat production potential of the camel is the lack of coordinated data (Wilson, 1984). The available literature indicates that camel meat is generally comparable with other red meats (beef, lamb and goat) in terms of carcass quality, and in particular in the composition of the main nutrients (Alkahal, 1994). However, compared with beef, camel meat has a higher inorganic mineral and moisture content and lower fat (Alkahal, 1994). A study by El-Magoli et al (1973) indicated that the levels of cholesterol in camel sirloin were lower than in beef sirloin (50 mg/100 g and 65 mg/100 g, respectively), making camel meat healthier. The quality of meat produced from young camels (under five years old) is comparable to beef in taste and texture (Alkahal, 1994). Estimates of dressing percentages range from 50 – 70% (Babiker and Tibin, 1988). Males have a higher dressing percentage than females; Wilson (1978) reported 51% for males and 47% for females, whereas a recent study by Kurtu (2004) indicated 54% and 50%, respectively.

Camel meat is regarded as a high quality food and therefore, readily eaten by nomadic communities that rear them, and also by those in urban centres from camel keeping tribes. However, in pastoral production systems, camels are generally too valuable to slaughter and are therefore not eaten frequently. It is preserved for special rituals like marriage ceremonies and religious occasions where a large number of people have to be fed. Even during such occasions, female camels are hardly slaughtered. In recent years, however, sale of live camels, usually males and unproductive females for slaughter, is very common in Kenya and there are now increasing numbers of camel butcheries in many urban centres (Farah, 2004a). In Kenya, majority of camels slaughtered in major cities are bought from the ASAL areas in northern Kenya and this contributes to household incomes for the pastoralists. There is also occasional export of slaughter camels to the Arabian Peninsula, a market that is not fully exploited. Theoretically, 1.5 – 7.5% of a population could be slaughtered or exported each year without causing a long-term decline in the population (Wilson, 1984). In practice, the actual offtake is estimated at between 1% and 5% (Simpkin, 1993).

2.3.2 Camel milk

It is difficult to estimate the daily milk yield of a camel under pastoralist conditions owing to the inconsistency of milking frequency. Milk yield is the most controversial subject concerning camels. For example, Herren (1992) observed that the majority of literature on camel milk production is controversial and often muddled by a failure to distinguish between two different issues: total (milked-out) yield and actual offtake for human consumption that still allows the calf to survive and grow. In the present study, the term milk yield is used to mean total milk yield (i.e. milked-out, complete extraction of the milk).

In one of the very few long-term studies covering full lactation periods, Bekele et al. (2002) demonstrated the potential of camels as dairy animals under traditional pastoral management. Seasonal variations in camel milk production are high (Farah, 1996b; Bekele et al., 2002; Muliro, 2007). A number of factors influence milk production and may be responsible for the large differences in the reported figures. These factors include: feed quantity and quality, breed, climate, watering frequency, stage of lactation and frequency of milking (Yagil, 1985; Simpkin, 1995; Ramet, 2001; Bekele et al., 2002; Farah, 2004b). Camels are usually milked twice a day – morning and evening; however, if the need arises they can be milked every 2 – 3 hours (Farah et al., 2004a). Bekele et al. (2002) reported the number of milkings per day ranged from 1 to 4 for camels under traditional pastoral management in eastern Ethiopia. Wernery (2003) states that camels must be milked 4 to 6 times a day to gain optimal milk yield. In Kenya, it is highly likely that the reported milk production levels fall below the genetic potential of the camels (Simpkin, 1993; Onjoro, 2004). Simpkin (1993; 1995) indicated the following as some of the reasons for low milk yields in Kenyan camels: (i) camels in Kenya are kept in marginal areas and receive no feed supplementation, (ii) there is little or no disease control, and (iii) camels have been kept for subsistence rather than commercial purposes, hence there has been little quality control. The producers considered the quantity rather than quality of the animals as being more important. Estimates of milk yields from various countries are presented in Table 2.2. The available data are highly speculative and should be considered as guidelines for milk yields under pastoral conditions. It should also be noted that throughout lactation, calves are still suckling and therefore the actual volumes of milk secreted are higher than the figures presented in the Table (Farah, 2004b).

Table 2.2: Milk yields of camels reported from various countries

Country	Average daily yields in Kg	Lactation length in months	Calculated yield in Kg per 365 days
Algeria	4	9 – 16	1460
Ethiopia	5	12 – 18	1825
India	6.8	18	2482
Kenya	4.5	11 – 16	1643
Pakistan	8	16 – 18	2920
Somalia	5	9 – 18	1825
Tunisia	4	9 – 16	1460

Source: Farah (2004b).

Milk yields

Milk production levels have been reported in various publications, mainly in the form of estimates. Although there are fewer long-term studies covering full lactation period, it is widely recognized that, in absolute terms, the camel produces more milk and for a longer period of time than other livestock species under harsh environmental conditions (Bekele et al., 2002; Farah et al., 2007). In drylands under average grazing conditions, a camel can produce 1,900 litres of milk a year for human consumption (Stiles, 1995). Under the same conditions, it is estimated that a cow, a sheep and a goat would produce 300, 59, and 88 litres, respectively. Schwartz and Walsh (1992) estimated lactation yield for East African camels at between 1,500 and 2,500 litres.

Daily yields

According to Wernery (2003) good milkers can produce 20 to 30 litres daily. Average daily milk yield of the Somali breed camels is reported to range from 5 to 8 litres (Bekele et al., 2002; Farah, 2004b; Farah et al., 2004a). Under exceptionally favourable conditions, Somali camels can potentially produce more than 15 litres of milk a day during the peak of their lactation (Farah et al., 2004a). Ramet (2001) had also reported that under more intensive systems camels can yield up to 12 to 20 litres a day. In Kenya, different daily milk yield figures have been reported for camels under traditional pastoral management systems. For example, Simpkin (1993) gave a range of 2.4 to 4 litres per day while Simpkin et al (1996) estimated the yield at between 3 to 7 litres per day. Onjoro (2004) states that the yield can improve to over 10 litres per day with better feeding. In the neighbouring Eastern Ethiopia, Baars (2000) reported camels' daily milk yield range between 3.6 and 6.5 litres per day while Bekele et al (2002) estimated the mean daily yield for camels under pastoral management in semi-arid eastern Ethiopia at 4.14 litres per day. In addition, Bekele et al (2002) observed that the daily milk yield varied according to the number of milkings per day and ranged from 1.26 litres per day for one time milking to 6.77 litres per day for four times milking. With the exception of Dereje and Uden (2005a), little has been done to study milk production under supplementary feeding regimes. Low milk production in pastoral camel system may be due to inadequate quantity and quality forages (Onjoro, 2004). There appear to be two peaks (Simpkin, 1995; Aloo et al., 2010) in the lactation curve – the first is very marked and occurs in the first 6 to 10 weeks of lactation; the second corresponds to the following wet season when forage is again plentiful (Simpkin,1995). However, Field (1979) and Bekele et al (2002) reported that daily yields peak between 10-20 weeks after parturition, thereafter tailing off to give very low yields at the end of lactation.

Lactation length

Estimates of lactation periods vary from 9 to 18 months (Yagil, 1994; Ramet, 2001; Bekele et al., 2002). The average length of the lactation period in the camel is 12 months (Shalash, 1979).

Duration of lactation also depends on a number of factors, for example, the survival of the calf. Camels whose calf dies produce less milk and lactate for a shorter period (Field, 1979; Simpkin, 1985; Bekele et al., 2002). Pregnancy also influences the duration of lactation, and according to Field (1979) lactation usually ceases 4-8 weeks after conception; while Schwartz et al., (1983) estimate this at 12-16 weeks post-conception.

Milk quality and composition

Camel milk compares favourably with the milk of other farm animals (Farah, 1993; Guliye et al., 2000; Ramet, 2001). The major difference, which is of special importance, is the high levels of vitamin C in camel milk as reported by several authors (Yagil, 1985; Farah, 1993, Ramet, 2001; Farah, 2004b). Vitamin C content in camel milk (25-60 mg/l) is almost three times that of cows' milk (Farah, 1993 and 2004b). This is a vital contribution to the pastoralists' diet since fresh fruit and vegetables (the main sources of Vitamin C) are rare in arid areas. The milk is generally opaque white with sweet and sharp taste that is sometimes salty, depending on the type of fodder consumed and availability of drinking water (Farah, 1993 and 2004b). Compared to cow's milk, camel's milk sours very slowly and can be kept longer without refrigeration (Farah, 2004b), but after storing it readily ferments into yoghurt (Field, 2005). The pH of camel's milk ranges from 6.2 to 6.5 and the density from 26 to 35 (Farah, 2004b). Both density and pH are lower than those of cow's milk. There are greater variations in constituents of camel milk than in cow milk. A number of factors influence camel milk composition. These include: breeds, stage of lactation and milk production potential (Simpkin, 1993; Mal, 2000; Mal and Sena, 2007). For example, Mal and Sena (2007) found that protein content was highest while fat content was lowest in breeds with better milk production potential. The gross composition (%) of camel milk from various sources is given in Table 2.3. It is, however, important to note that camel milk composition is not very significant from local consumers' point of view since milk price is not yet based on its composition.

Table 2.3: Gross composition (%) of camel milk from various sources

Milk components	Range	Source
Fat (%)	2.90 – 5.40	Farah, 2004b
Fat (%)	2.90 – 5.38	Yagil, 1982
Fat (%)	1.95 – 2.99	Mal and Sena, 2007
Fat (%)	2.37 – 3.24	Mal, 2000
Protein (%)	3.00 – 3.90	Farah, 2004b
Protein (%)	3.37 – 4.22	Mal and Sena, 2007
Protein (%)	3.64 – 4.03	Mal, 2000
SNF (%)	7.01 – 10.36	Yagil, 1982
SNF (%)	6.97 – 7.94	Mal and Sena, 2007
SNF (%)	7.45 – 8.85	Mal, 2000
Density (%)	26.00 – 35.00	Farah, 2004b

Antimicrobial activity of camel milk

Camel milk is increasingly attracting interest due to its perceived medicinal properties by pastoral communities (Wernery and Wernery, 2010). It is also said to have anti-microbial activities (El-Agamy et al., 1992). Barbour et al., (1984) studied the ability of camel milk to inhibit growth of pathogenic bacteria and showed inhibition of four out of six pathogenic bacteria. In a recent review to establish evidence of the antimicrobial activities of camel milk, Faye (2007) reported that camel milk is a known cure for diabetes, tuberculosis, stomach ulcers, gastro-enteritis and cancer in the African Rift Valley and Asia. The author found evidence of some medicinal potential from reported analysis of camel milk. Compared to cow's milk, camel milk has ten times higher quantities of the protein, lactoferrin, with some anti-viral and anti-bacterial properties (Farah, 1996b; Faye, 2007). Exactly how lactoferrin exerts all of its immune modulating or immune enhancing functions is not entirely clear, but it is known to enhance the immune response both directly and indirectly (passively) in response to a wide range of immune challenges, and is an essential factor in the immune response in humans. Faye (2007) further reported that fermented camel milk is high in lactic bacteria, which are effective against pathogens including *Bacillus*, *Staphylococcus*, *Salmonella* and *Escherichia*.

2.4 Marketing of live camels and camel products

Under traditional pastoral production systems, camel production is mainly for subsistence. Consequently, the economic contribution of camel systems to national production (GDP) in the countries of Eastern Africa is not often known. In Kenya, for example, detailed information is available on exports of cattle, sheep and goats but the large numbers of camels that are known to be exported to the Middle East through Ethiopia (Personal observation) do not appear in official statistics. A recent study (Mahmoud, 2010) has confirmed the existence of a vibrant and lucrative live camel market in the northern Kenya border town of Moyale where several market actors (herders, traders, brokers) are making good gains. While cattle have largely remained commodity for local consumption, camels are being exported to the Middle Eastern countries in large numbers (Mahmoud, 2010). It is only recently that some formal marketing of live camels has started to emerge. Live camel offtake is estimated at between 1% and 5% (Simpkin, 1993). Camel meat is an important product mainly as a source of income. Sale of live camels, usually males and unproductive females for slaughter, is very common in Kenya and there are now increasing numbers of camel butcheries in many urban centres (Farah, 2004a).

There are a number of impediments to livestock marketing for producers from northern Kenya. These include: poor quality roads, lack of reliable market information, stock rustling and general insecurity, absence of consistent livestock marketing policies, and hence dependency on private traders (Chabari and Njiru, 1991). A major constraint to camel marketing is the lack of information concerning market prices due to the remoteness of camel rearing areas and associated poor communication infrastructure (Simpkin, 1993). However, Isiolo town is now a prominent camel market outlet for pastoral and peri-urban camel producers (Heath, 1997).

Camel milk, which has been consumed for centuries by nomadic people for its nutritional values and medicinal properties, is now experiencing greater awareness in the western world (Wernery and Wernery, 2010). There is now a camel farm in the Netherlands owned by a Mr. Frank Smits whose main customers are immigrants to Europe from Somalia and Morocco (Cromvoirt Journal, 2009). In addition, the Food and Drug Administration has also recently agreed to add camel's milk to its list of salable products in the United States, although it still cannot be sold or imported for human consumption until it passes a battery of tests (Cromvoirt Journal, 2009).

It is estimated that the Kenyan camel population is capable of producing between 340 and 350 million litres of milk (Faye, 2007; Akweya et al., 2010a) and 10,000 tonnes of meat a year (Faye, 2007). The health-promoting properties of camel milk are a strong boost for sales and, in certain regions such as the Middle East, they are the driver for intensification of camel dairying (Faye, 2007). In recent years, commercial exploitation of camel milk in Kenya has grown tremendously (Matofari et al., 2007). In the context of advancing urbanisation, camel milk is increasingly commercialised and consumed in urban areas. However, the main constraints of this emerging milk market are (i) poor hygienic quality of the commercialized milk and (ii) lack of milk processing technologies to improve shelf life and expand production and sales (Farah et al., 2004b; Matofari et al., 2007; Matofari et al., 2013).

Only about 12% of the Kenyan camel milk is marketed, the bulk of which is sold in raw form to rural consumers (10%) and only 2% reaches the urban consumers (Akweya et al., 2010a). The same authors state that from the remaining milk (88%) that does not reach the market, 38% is directly used by camel keeping households and their herders as part of their food requirements and the remaining 50% (or 170 million litres) goes to waste. Muliro (2007) also states that during the rainy season, much of the surplus camel milk goes to waste. There is, therefore, a great opportunity for commercialization and enhanced incomes for camel keeping pastoral communities (Muliro, 2007; Akweya et al., 2010a). In this regard, the camel milk industry potential in Kenya has already been picked up by one local firm, Vital Camel Milk, which has broken new ground by setting up a plant to process camel milk. The plant was commissioned in 2005 in Nanyuki town. It produces pasteurised milk which it sales to Supermarkets in Nairobi as a health-promoting product. The initiative by this company has compelled the Kenya Bureau of Standards (KEBS) to start working with stakeholders in the dairy industry to establish the code of hygienic practice and handling of camel milk (Muliro, 2007). The Kenya government has also recognized the potential contribution of dairy livestock such as camels and goats in addition to cattle in the overall milk production by including them in the dairy development policy currently undergoing review (Muliro, 2007).

2.5 Camel feeding and nutrition

2.5.1 Feeding habits and food intake

The camel is, by preference, a browser of a broad spectrum of fodder plants, including trees, shrubs, and sometimes hard-thorny, bitter and halophytic (salty) plants that grow naturally in the desert and other semi-arid areas (Coppock et al., 1986a; Wilson, 1989; Field, 1993). They generally browse leaves, young twigs/shoots, fruits, flowers and pods. Under natural conditions camels have the capacity to choose their forages efficiently, grazing more on forage trees than grasses (Field, 1993). Leaves from trees are generally richer in minerals than grasses (Kuria et al., 2004). An important feature of camels' browsing habits is that they are not in direct competition with other domestic animals either in terms of the type of feed eaten or in the height at which they eat above the ground (Wilson, 1989). The greatest competition for feed resources is found between camels and goats, with 47.5% dietary overlap in the dry season and 12.4% in the green (wet) season (Wilson, 1998). From an extensive set of feeding observations in five different range types in Marsabit County of northern Kenya, Field (2005) calculated the average composition of the diet of camels as follows: Trees (25%), Dwarf shrubs (50%), Herbs (14%)

and Grasses (11%). The predominant forage species consumed by camels in northern Kenya include *Acacia*, *Cordia*, *Duosperma, Euphorbia*, *Grewia*, *Indigofera* and *Salvadora* (Schwartz et al., 1983; Evans et al., 1995; Wilson, 1998; Onjoro, 2004). Field (1995) noted seasonal variations such that trees, shrubs and dwarf shrubs dominated camel diet in wet season but the percentage of trees and shrubs noticeably declined during the dry season when most of these species shed off their leaves. During drought, there is a tendency for camels to concentrate on evergreen shrubs and trees such as *Dobera glabra*, *Salvadora persica* and certain *Euphorbia* species (Yagil, 1994; Field, 1995).

There is still little known about the amounts of feed eaten by camels, especially under free-ranging conditions. Published results are, to some extent, conflicting but it does appear that intakes of feed per unit of body weight are low compared to other domestic species (Field, 1995; Wilson, 1998). Reasons for the observed differences in food intake for camels and other livestock may relate to their lower metabolic rate and their more nutritious diet (Field, 1995). The quantity of feed eaten by a camel depends on the water content of the forage. If a camel eats 30 – 40 Kg of fresh fodder which has a water content of 80%, then the intake is only 6-8 Kg dry matter (Yagil, 1994). Camels' feed intake also depends on its selective feeding of a wide variety of vegetation and different parts of browse which differ in quality (Wilson, 1989; Hashi et al., 1995). For example, ingestion rates can be rapid where preferred or selected browse is plentiful but are much slower on thorny species that have little leaf. Kassily (2010) also states that forage quality influences feeding activity patterns in camels and that under adverse pasture conditions, the time available for grazing would be a limiting factor for their total dry matter and nutrient intake. Detailed nutritional studies in the arid lands of northern Kenya have shown that the small-bodied Rendille/Gabbra camels consume daily 1.67% of their live weight. Consequently, the daily dry matter intake (DMI) calculated by multiplying this figure by actual mean live weight resulted in 5.02 kg per day (Field, 2005). To allow for production costs, the DMI calculation for camels should be increased by 10%, thus giving 5.52 kg per day (Field, 2005). However, according to Wilson (1989), camels' total dry matter intake needs to be about 4% of body weight and that feeding times required to satisfy this requirement may be as much as 15 or more hours per day. Consequently, a mature camel weighing 650 Kg would require about 26 Kg of dry matter, which might represent between 80 and 100 Kg of total food intake of plants with high moisture contents.

2.5.2 Camel feeding strategies and their limitations

Pastoral (nomadic) camel production system is characterized by herd mobility and seasonal migration in communal rangelands in search of better quality resources (pastures, water and mineral licks). The system is highly efficient and has been used by camel herders for centuries. For example, Dereje and Uden (2005b) state that in traditional long-range nomadic systems, the diet of camels with mixed feeding behaviour can be extraordinarily varied. This habit limits the risks of nutritional deficiencies and the vegetation selected is also of a fairly good quality (Dereje and Uden, 2005a). Wilson (1998) states that camel pastoralists have a sophisticated resource-use system that uses mobility, social cooperation and intensive labour inputs as part of their survival strategies. However, increasing human population pressure on pastoral grazing areas (Farah et al., 2004a) have almost certainly resulted in environmental degradation and dwindling of feed resources (Wison, 1998).

Pastoral camel herders in northern Kenya adopt rational and goal-oriented camel management strategies in utilising their rangeland environments (Farah et al., 2004a). Such strategies include movement of their animals in the range in order to locate ideal grazing areas and water resources, and also establish suitable patterns of movements. Another strategy is that of herd splitting in order to cope with production resource constraints and spread risks.

Under peri-urban (sedentary) camel production systems, the once desirable mixed exposure and intake to feed is being lost (Dereje and Uden, 2005a). A number of factors can be attributed to the low productivity observed, but feed shortage, both in quality and quantity, is probably the most important single factor (Dereje and Uden, 2005a). The reason for this is that, unlike in pastoral system, peri-urban system does not allow seasonal herd mobility in the rangelands for greater exploitation of the scarce resources. The shift from pastoral to peri-urban camel production restricts camels to limited feed resource base. This is particularly evident in Isiolo, northern Kenya, during dry season and droughts where there is pressure on feed resources forcing camel keepers to feed their camels on *Euphorbia tirucalli* (Field, 1995; Maundu and Tengnas, 2005), a succulent non-conventional forage for camels, whose nutritive value and its effect on milk quality is unknown. An additional effect of feed resource pressure is rampant enclosure and unlawful privatization of communal rangelands by different communities. In Isiolo peri-urban area this has at times resulted in inter-tribal conflicts, necessitating quick intervention by the provincial administration arm of the Kenyan Government.

In view of the trend towards peri-urban systems, there is an urgent need to investigate ways of improving the nutritional conditions of the camels in order to increase milk production and thereby improve the life of camel producers. The underlying assumption is that improvements can be achieved by introducing energy and protein-based diets that are relatively cheap and locally available supplementary feeds. Furthermore, in the absence of development of scientifically proven nutritional guidelines for camels, some trial and error will need to be carried out to determine for any particular area which are the best feeds and in which proportions, while giving due consideration to the important question of cost (Wilson, 1998).

2.5.3 Nutrient requirements of camels

Despite mounting interest in camels and camel production research witnessed in the last two to three decades, knowledge of camel's nutritional requirements to provide sufficient information necessary for systematic feeding for efficient and profitable production is still limited (Farid, 1995; Wilson, 1998). This can be explained by the fact that, for long, the camel was rarely managed for commercial purposes. More research is therefore required on feeding and nutrition (Wardeh, 1994). There has so far been little experimentation on feeding standards for camels performing different functions (Wilson, 1989). Guidelines for camel feeding have often been extrapolated from the feeding standards for cattle, assuming that the digestibility of foods by camels and their efficiency of utilization of nutrients for various functions do not differ significantly from those of true ruminants (Hashi et al., 1995). Energy and protein are the most limiting nutritional factors. Both are required for maintenance and production. The demands for milk production are high in terms of energy. The requirement for one litre of milk is equivalent to almost 10% of the maintenance requirement. In terms of protein, milk is even more demanding of nutrients and one litre requires about 20% of the maintenance requirement of a 400 Kg female camel (Wilson, 1989). Table 2.4 provides an indication of the energy and protein requirements of a 400 Kg female camel. According to Wilson (1989), for example, the daily requirements for 15 Kg of milk could not be met from free-range grazing and a concentrated feed would be required. However, work by Hashi et al., (1995) suggests that camels have lower energy requirements and/or extract more from fibrous feeds. In addition, camels producing milk have a need for large quantities of water (milk is about 90% water) (Wilson, 1998). Table 2.5 highlights some energy and protein feeds suitable for camels.

Table 2.4: Energy and protein requirements of female camels of 400 Kg live weight

	Requirement	
	Energy MJ ME	Protein g DCP
Daily maintenance	45	260
Milk production – 1 litre	5	50
Daily requirement for maintenance plus peak yield of 15 litres milk	90	1,010

Source: Wilson (1989).

Table 2.5: Energy and protein feeds suitable for camels

Feed	Type of nutrient supplied		
	Energy	Protein	Energy + Protein
Standard concentrate mix			***
Cereal straw	**		
Young green grass/legumes	**	***	
Grass hay	**	**	
Legume hay	**	***	
Oil seed cakes	*	****	
Wheat bran	**	**	
Cereal grains	***	**	
Pods of legume trees		***	
Leaves of legume trees		***	

Legend for nutrient contribution: *Low, **Moderate, ***High, ****Very high
Source: Wilson (1998).

Since time immemorial, camel owners have recognised the need for salt for their camels. Consequently, they expend enormous effort in periodically taking their animals to salt deposits or saline water points, or transporting salt to their animals (Evans et al., 1995). For example, minerals, in form of common salt (sodium chloride), were commonly used as a nutritional additive in Sudanese camels (Ishaq and Ahmed, 2011). This is a clear indication that camel owners understood, perhaps for many generations, the importance of salt as a dietary component for camels, and this is part of their traditional management practices. Mineral intake may determine the level of milk production in camels (Onjoro, 2004; Onjoro et al., 2006). Forages and drinking water are the main sources of minerals for camels and other animals (McDowell et al., 1995; Onjoro, 2004). Camels feeding on natural forages will normally take in enough minerals and vitamins for their needs (Wilson, 1998). Camels prefer browse forages which has relatively higher calcium levels although it is rather poor in phosphorus (Field, 1993). Some range plants provide minerals of unknown quantities to animals which are seen preferring them at particular times of the year (Onjoro, 2004). Camels, in particular, go for halophytic (salty) plants such as *Sueda monoica*, *Salsola dendroides* and *Salvadora persica* (Field, 1993; Kaufmann, 1998). The halophytic shrubs have ash contents as high as 25 – 27%, mostly in the form of sodium chloride (common salt) (Field, 1993). Most naturally occurring mineral deficiencies in forages are due to specific regions and are directly related to soil characteristics and/or geological origin (Onjoro, 2004). Mineral deficient animals often consume considerable amount of earth (soil) but mineral amounts in soils are extremely variable (McDowell et al., 1995). In certain cases animals directly lick soils of particular origin to make up for deficient macro minerals or trace elements. For example, camels in northern Kenya have been reported (Kaufmann, 1998; Noor, 1999) eating anthills, a behaviour indicative of some kind of deficiency, which might be a mineral deficiency. Some macro mineral deficiencies reported in Kenya include magnesium, phosphorus and sodium (McDowell et al., 1995) while deficient trace minerals include copper and cobalt (McDowell et al., 1995; Onjoro, 2004). Because some minerals (calcium, phosphorus, copper and cobalt) are associated with energy metabolism, their deficiency may lead to reduced milk yields (Onjoro, 2004). The mineral requirements of camels are not yet documented (Onjoro, 2004; Onjoro et al., 2006), and data on individual mineral concentrations and seasonal variations in mineral status in forage species are scanty.

2.5.4 Nutritive value of some forages preferred by camels

Animals adapt to fluctuations in forage quality by either selectively eating plants of high quality or by improving the digestion of poor forage through a longer retention time of ingesta particles in the forestomach (Rutagwenda et al., 1990; Lechner-Doll et al., 1990). However, the ability to feed selectively and to improve the digestion of the selected forage varies from one animal species to another (Rutagwenda et al., 1990).

Camels are selective feeders, having access to browse outside the range of other livestock. Camels consume a high protein diet if available, but if forced to feed on low quality fibrous diets they are able to recycle and use body urea efficiently (Field, 1995; Wilson, 1998). Unlike other ruminants, camels have a higher capacity to utilize fibrous feed material by retaining it in the rumen for longer period, allowing for better digestion (Lechner-Doll et al., 1990; Wilson, 1998). This mitigates the negative effects of high fibre content in camel diets. The camels' ability to select high quality feed is helped by the long and grasping upper lip and mobile tongue (Wilson, 1998). In addition, it has access to feed not available to other domestic species, even the goat, because of its height.

The nutritive value of any feedstuff is determined by the amount of digestible dry matter ingested by the animal (Sawe et al., 1998). It is well documented that the dry matter digestibility is positively correlated to CP content and negatively correlated to crude fibre, acid detergent fibre, and neutral detergent fibre (Sawe et al., 1998).

Protein requirements in ruminants include protein and/or nitrogen requirements for the ruminal microbial population (Kuria et al., 2005). The microbial requirements are met at 6 – 8% CP while the animal requirements range from 7 – 20% CP in the diet depending upon species, sex and physiological state (Kuria et al., 2005). Studies carried out in Marsabit County (Field, 1993), over a period of 42 months, revealed the estimated crude protein (CP) intake of camels at over 10%, while Wilson (1998) indicated that Kenyan camels are able to maintain a diet with a minimum CP content of 14% in the dry season. The CP content of forage species selected by camels increase from dry to wet season (Field, 1995).

Neutral detergent fibre (NDF) is the major determinant of overall forage quality and digestibility, and has a direct effect on animal performance. NDF is closely related to feed intake because it contains all the fibre components (hemicellulose, cellulose and lignin) that occupy space in the rumen and are slowly digested (Ensminger et al., 1990). High NDF lowers the voluntary DM intake of grazing animals. The higher the NDF, the lower the neutral detergent solubles i.e. starches, sugars, fat, CP. The lower the NDF, the more forage the animal will eat; hence, a lower percentage of NDF is desirable. Acid detergent fibre (ADF) is an indicator of forage digestibility because it contains a high proportion of lignin which is the indigestible fibre fraction. NDF will always be a higher number than ADF because ADF does not contain hemicellulose. The lower the ADF, the more feed an animal can digest. Hence, a low ADF percentage is desirable (Ensminger et al., 1990). Kuria et al (2005) reported mean CP and NDF contents of preferred camel forages as 13.9 ± 5.0% and 53.6 ± 13.7% of DM, respectively. Table 2.6 presents the results of chemical analysis of some range forage species found in Isiolo County, northern Kenya, preferred by camels (Schwartz, 1992b). The means, standard deviations, minima and maxima are listed, to give an impression of the seasonal changes which were observed. Highest fibre and lignin contents were reached at the end of the dry seasons while highest crude protein contents are at the beginning of the rainy seasons. Documented *in vitro* dry matter digestibility (IVDMD) of some camel browse plants showed a wide range of 0.23 – 0.78 (Dereje and Uden, 2005b).

Table 2.6: Nutritive quality (% DM) of some forages preferred by camels

Forage species	NDF	ADF	ADL	Ash	CP
Acacia mellifera					
• Mean	36.84	24.40	7.11	10.00	20.76
• S.D.	8.00	5.68	1.86	6.09	6.38
• Maximum	53.37	38.61	12.63	29.79	29.68
• Minimum	21.59	12.95	5.19	4.66	8.10
Cordia sinensis					
• Mean	39.76	35.78	14.71	13.92	17.59
• S.D.	5.71	8.01	4.75	2.17	4.19
• Maximum	47.94	46.02	20.96	18.80	24.20
• Minimum	28.55	21.96	7.22	11.90	11.44
Indigofera spinosa					
• Mean	49.67	38.17	9.52	9.41	13.71
• S.D.	10.57	10.08	4.03	1.91	5.00
• Maximum	66.76	53.38	15.81	13.86	31.32
• Minimum	27.91	17.29	2.12	6.27	7.60

NDF=Neutral Detergent Fibre, ADF=Acid Detergent Fibre, ADL=Acid Detergent Lignin and CP=Crude Protein.

Source: Schwartz (1992b).

Table 2.7 presents a summary of seasonal nutritive contents of major forage species in camel diets, Central Somalia (Elmi, 1991). This is an arid area with natural vegetation similar to what is found in northern Kenya. Seasonal changes in nutrient content of forages selected by camels would result in changes in the diet quality, which directly affect camel performance and the subsequent well being of camel keepers (Kuria et al., 2005).

Table 2.7: Seasonal nutritive contents of major forage species in camel diets, Central Somalia.

Nutrient contents		Dry season %	Wet season %
Crude protein		16.3	24.1
Invitro dry matter digestibility		35.5	39.2
Neutral detergent fibre		66.9	65.3
Acid detergent fibre		50.3	49.8
Acid detergent lignin		13.4	14.7
MINERALS	- Calcium	1.9	1.8
	- Phosphorous	0.1	0.1
	- Potassium	1.3	1.7
	- Sodium	0.3	0.2

Source: Elmi (1991).

2.5.5 Supplementary feeding of camels

Camels are free-ranging animals and under many circumstances need little of additional food if not performing extra work or producing large quantities of milk (Wilson, 1998). Work animals usually require more energy in their diets while milking animals require more protein (Yagil, 1994). The traditional camel herdsmen rarely provide supplementary feeds to their camels, other than salt (sodium chloride) or allowing access to salty water and halophytes (salty plants) (Elmi, 1991; Farah et al, 2004a). Thus, there is lack of information on how the evolving peri-urban production system influences the feeding management strategies, and the constraints and opportunities that camel producers face. Simpkin (1995) states that supplementary feeding or zero grazing of camels would only be worth implementing in the more arid areas, using high producing animals, in locations where supplementary fodder is locally available, and where there is a local market for the milk. When choosing supplementary feeds for camels, feed availability, its nutritive value and cost should form the guiding principle. Supplementary feed for camels can be provided in the form of pods of certain trees, such as *Acacia* trees. Other supplementary feeds can be millet, straw, sorghum, cottonseed, hay, oats, dates and other energy-giving fodder (Yagil, 1994; Wilson, 1989). According to Hashi et al. (1995) consumption of low quality roughages and total feed intake by camels can be improved with supplementary feeding. For example, a concentrate feeding experiment resulted in a highly significant improvement (by as much as 16%) in oat hay consumption, while lactating camels in another feeding experiment formulated so that it would be appropriate for true ruminants had an average production of 6 litres and showed a positive live weight change (140 g per day). However, calculations of feed requirements for the camel still rely heavily on data and constants generated with cattle, and, therefore, more practical field experimentation work is needed before reliable feed budgets can be developed within defined production patterns (Hashi et al., 1995). Only then, will it be possible to design solutions (i.e. supplementation protocol) for the nutritional constraints that limit increased and sustained productivity.

There are no documented deficiencies of minerals in the diets of camels. However, clinical symptoms of skin and bone diseases suggest that in some areas the fodder is deficient and mineral supplementation is required (Yagil, 1994), and this can be achieved by providing a mineral lick that contains the necessary elements (Wilson, 1998). As stated earlier, with the exception of Dereje and Uden (2005a), little work has been done to study milk production in camels under supplementary feeding regimes. In their study, Dereje and Uden (2005a) reported that lactating camels on range in Eastern Ethiopia substantially increased milk yield when supplemented with protein or energy feeds.

CHAPTER THREE

CHARACTERISTICS OF THE EMERGING PERI-URBAN CAMEL PRODUCTION SYSTEM IN ISIOLO COUNTY, KENYA

3.1 Introduction

Peri-urban camel production system (PUCPS) is emerging from subsistence pastoral system in urban areas of northern Kenya (Mehari et al., 2007a and 2007b). The emerging system has the potential of adding value to camel milk and improving the livelihoods (LPP, LIFE Network, IUCN-WISP and FAO, 2010) in the ASALs where poverty incidences at 65% are the highest in Kenya with livestock accounting for 90% of the employment and over 95% of the family incomes (SRA, 2004). Despite this potential for changing livelihoods in the ASALs, little is known of the behaviour and characteristics of the emerging peri-urban camel production system. Free herd mobility utilising extensive rangeland grazing resources practiced in traditional pastoral system is considered a sustainable way of utilising the ASALs (Sombroek et al., 1982; Behnke and Scoones, 1993; Kaufmann, 1998). Therefore, the emerging peri-urban camel production system with grazing restricted to feed resources within the vicinity of urban market outlets for milk and stock could present challenges not yet understood by camel producers and development agencies interested in supporting the development of such a system.

This study seeks to answer the research questions: what are the key characteristics of the emerging system?; what are the drivers for its development?; and what is the extent of vulnerability to droughts and disease incidences? Empirical evidence obtained will objectively inform development agencies of appropriate interventions for sustaining market-led camel production in Kenya's ASALs.

3.2 Materials and Methods

3.2.1 Study area

The study was conducted in Isiolo County, a typical ASAL area in northern Kenya, purposively selected for the study because of the presence of an emerging peri-urban camel production system alongside pastoral camel system. Isiolo town is the headquarters of the County. It is a semi-arid area that experiences frequent droughts with devastating losses of livestock and human lives. The County has bimodal rainfall pattern, but unpredictable and erratic in distribution. Long rains come in late March through May and short rains in November to December, with most parts of the County having mean annual temperatures between 24^{o}C and 30^{o}C (Herlocker et al., 1993). Under these conditions, rain-fed agriculture is unsustainable.

Isiolo County falls within three agro-climatic zones: i) semi-arid, occupying 5% of the area, ii) arid, occupying 30%, and iii) very arid, occupying 65% of the area (Sombroek et al., 1982;

Herlocker et al., 1993). The County covers a total area of 25,605 km^2 located between Longitude 36°50' and 39°30' East and Latitudes 0^{o}5' and 2° North (Figure 3.1). The County is generally flat, low lying plains with altitudes ranging between 180 m above sea level at Lorian Swamp in the northern part to 1000 m above sea level in the southern part. Volcanic hills formed as a result of volcanic activities of the now dormant Mt. Kenya form the western part of the County.

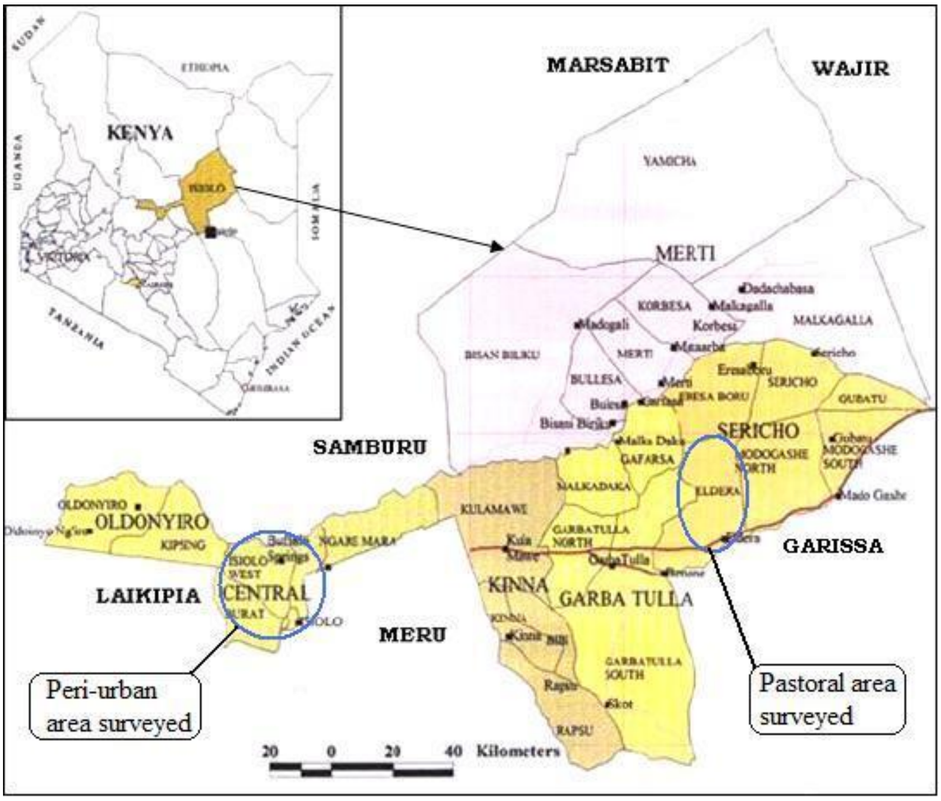

Figure 3.1: Map of Isiolo County in northern Kenya, showing peri-urban and pastoral camel areas surveyed.
Source: Guliye et al. (2008).

3.2.2 Data collection

Two cross-sectional surveys (Plate 1) were conducted in February 2007: one within the peri-urban area of Isiolo town where there is an emerging camel production system and the other in the pastoral rangelands of Isiolo County where traditional attachments to socio-cultural roles of camels remain strong (Figure 3.1). The peri-urban camel system has milking herds reared within the vicinity of Isiolo town where there is a thriving market for camel milk, meat and live animals. Pastoral camel system serves subsistence roles and has minimal market integration and access to veterinary and extension services. The herds are larger and more mobile in the vast rangelands in search of pasture, water, mineral licks and security from ethnic resource-based conflicts.

Plate 1: An enumerator interviewing camel herders in a pastoral production system in Eldera area of Isiolo County (Kenya).

Due to the mobility of pastoral herds and necessity for consent of the herd owners in accessing their herds, sampling of the peri-urban and pastoral herds was limited to accessible herds whose owners were willing to participate. The sampling captured 70 pastoral herds and 60 peri-urban herds. The individual herds formed the sampling units and the herd owners interviewed provided the primary data. Trained enumerators that spoke the local languages (Boran and Somali) and supervised by the author, administered pre-tested structured interview guides (Appendices 1 & 2). Information collection focused on relative importance of the various livelihood sources, sourcing of foundation camel herds, camel herd structures, feed resources and production constraints and mitigation strategies applied. Also, camel herders were asked to mention important camel browse forages frequently browsed during wet and dry/drought seasons for identification and sample collection for nutritive value analysis.

A focus group discussion (FGD) of camel stakeholders was organised in Isiolo town to complement information from the surveys. The stakeholders included: camel producers, camel milk traders, representatives of government departments, non-governmental organizations (NGOs), community based organizations (CBOs), and local leaders. Camel producers and milk traders were the majority (70%). Stakeholders in FGD mapped the emerging process of Isiolo peri-urban camel production system, constraints faced and mitigation strategies adopted.

3.2.3 Data analysis

Comparative descriptive and inferential statistical analysis of pastoral and peri-urban camel systems was done for relative importance of livelihoods and values attached to camels, drivers of peri-urban camel production system and ranking of constraints and the mitigation strategies frequently applied. The independent *t-tests* were applied to data with normal distribution and Mann-Whitney rank-sum test to ranked measures and continuous data lacking in normal distribution (Petrie and Watson, 1999). Count data were subjected to *chi-square* test statistics.

3.3 Results

3.3.1 Importance of camels as a livelihood source

Livestock keeping is the livelihood base for the majority of households (83.3%) in Isiolo County and camels ranked the most important ($P<0.05$) livelihood source in both pastoral and peri-urban systems (Figure 3.2). Camels are more important source of livelihood even for peri-urban households, with only a few (16.7%) engaging in other alternative livelihoods. The main reasons for keeping camels varied between the peri-urban and pastoral production systems. Figure 3.3 illustrates the relative importance of the different camel products and services to the camel keepers in Isiolo County. In the peri-urban camel system, camels are valued more ($P<0.01$) for milk for selling while in pastoral system camels are valued more for progenies to sell ($P<0.01$), for transportation ($P<0.001$) and for socio-cultural roles ($P<0.01$).

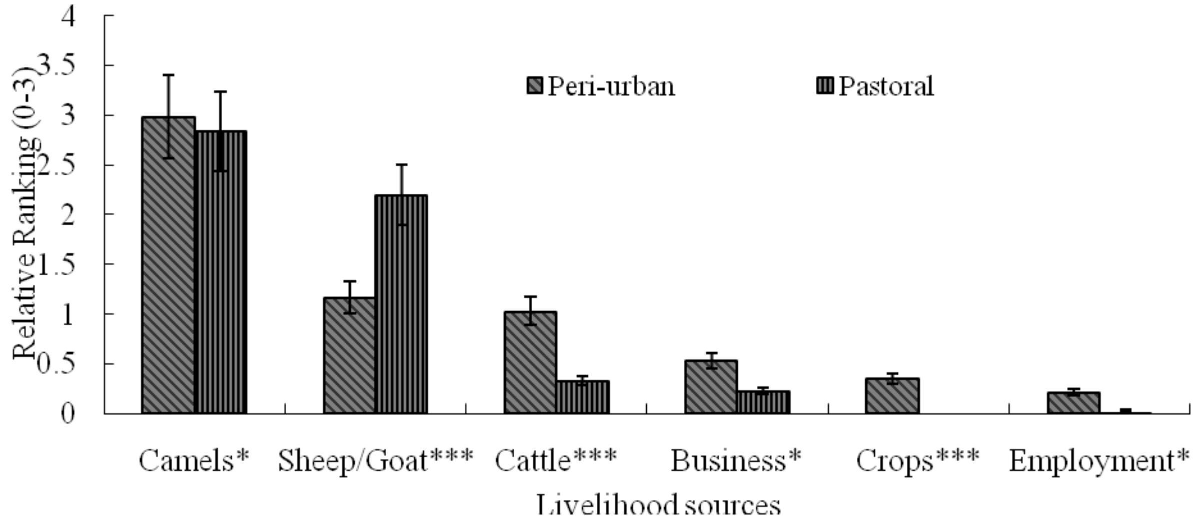

Figure 3.2: Relative importance of livestock and non-livestock livelihood sources among pastoral and peri-urban camel producers in Isiolo County, northern Kenya (*= *P*<0.05; **=*P*<0.01; ***=*P*<0.001).

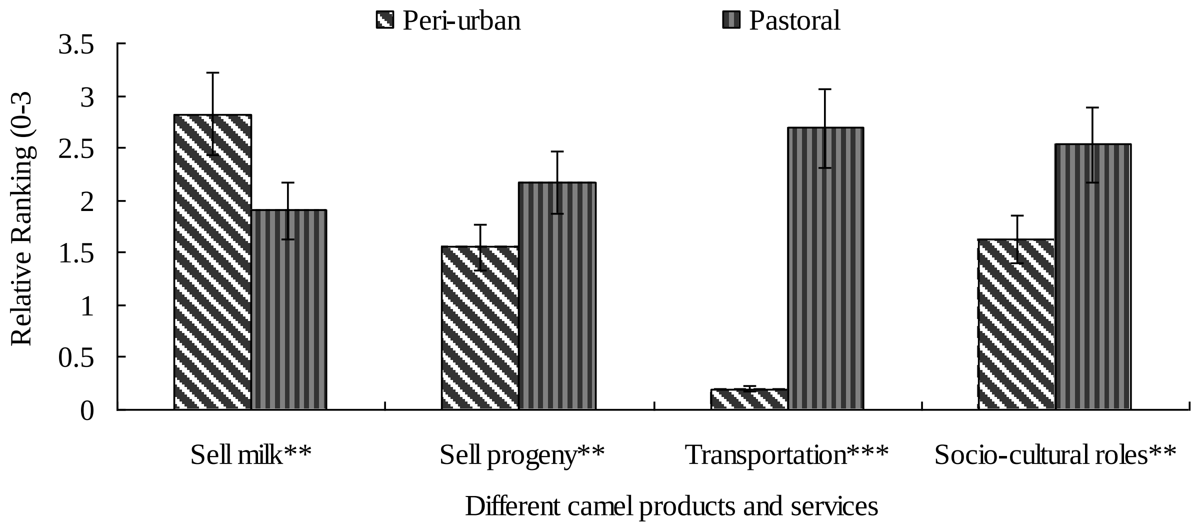

Figure 3.3: Relative importance of the different camel products and services to the pastoral and peri-urban camel producers in Isiolo County, northern Kenya. (**=*P*<0.01; ***=*P*<0.001).

3.3.2 Emergence of Isiolo peri-urban camel production system

Figure 3.4 illustrates the emergence of market-oriented camel production system from subsistence system while Figure 3.5 illustrates the growth process traced with the help of stakeholders in a Focus Group Discussion (FGD).

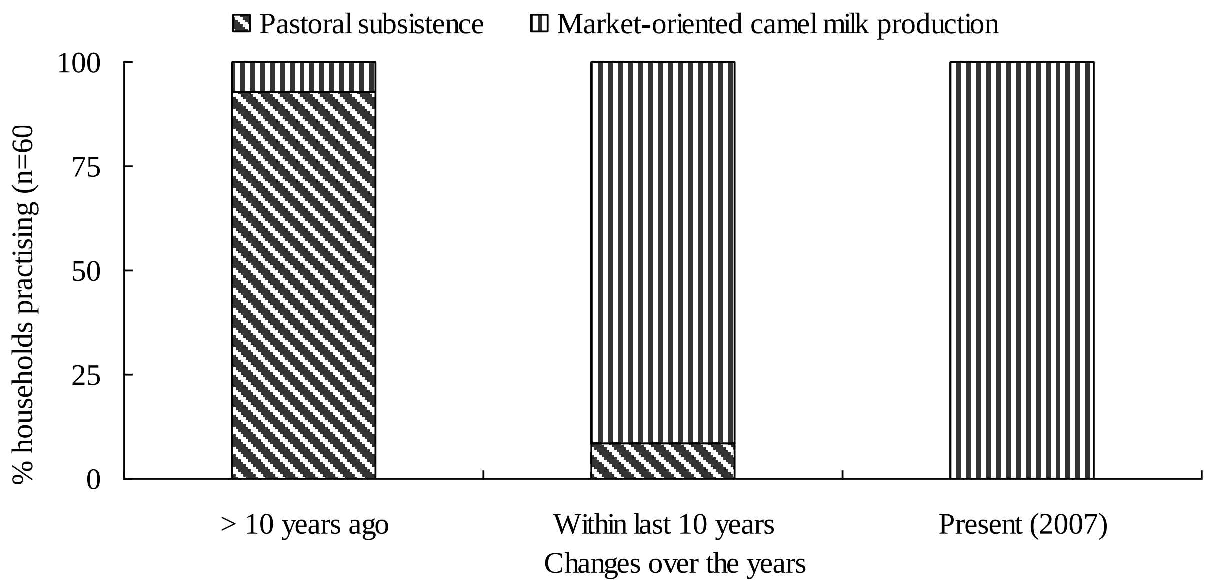

Figure 3.4: Emergence of Isiolo peri-urban camel production system.

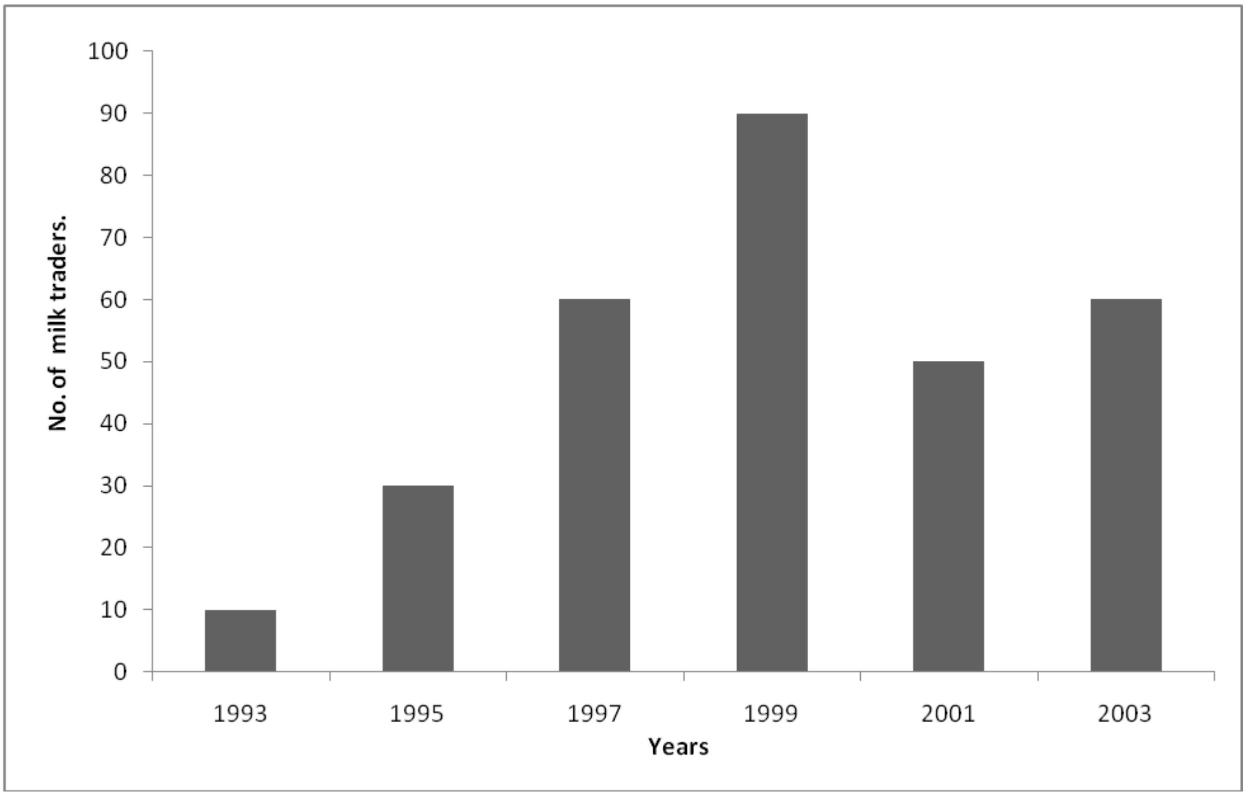

Figure 3.5: Growth trends of camel milk traders in Isiolo.

Results indicate that the emergence of this system began in the early 1990s (Figure 3.4) and the steady increase in the number of camel milk traders from 1993 (Figure 3.5) would suggest that the system was market triggered, then seized by entrepreneurs.

Discussions with camel stakeholders in FGD revealed that expansion in demand for camel milk in Nairobi urban market attracted a concomitant increase in camel milk producers and traders in Isiolo town. With more of the pastoral households settled in Isiolo town, they increasingly adopted keeping of milking herds within reach in order to sell the milk in urban outlets while others engaged in milk trade by bulking milk in Isiolo town and transporting to Nairobi urban market using public transportation. According to camel stakeholders, the decline in the number of camel milk traders between 1999 and 2001 was due to resource-based conflicts amongst ethnic communities in Isiolo area during that period.

3.3.3 Investment in peri-urban camel production enterprises

Table 3.1 presents results on the sources of foundation camel herds for peri-urban and pastoral production systems of Isiolo County, showing that the two systems build their herds differently. In the peri-urban system, majority (60%) of camel producers purchased their foundation stock, reflecting direct investment in asset accumulation. In contrast, most (81.4%) producers in pastoral system built their herds from inheritance, reflecting the traditional strategy of asset accumulation.

Table 3.1: Sources of foundation herds in peri-urban and pastoral systems of camel production in Isiolo County of northern Kenya

Source of foundation stock	Peri-urban system (n=60)	Pastoral system (n=70)	*Chi-square* test	
			$\chi 2$ - value	*P*-value
Inheritance only (%)	26.7	81.4		
Purchase only (%)	60.0	14.3	39.46	0.000
Inheritance and purchase (%)	13.3	4.3		

Figure 3.6 illustrates the herd structures where the herds in peri-urban system, compared to pastoral system, have a larger (P<0.05) proportion of breeding females (0.55 *vs* 0.48) and less (P<0.05) breeding males (0.03 vs 0.07). This difference in herd structure reflects a change in production objective towards commercial milk production in the peri-urban system. In addition, peri-urban system has higher numbers of immature females though the difference is not statistically significant.

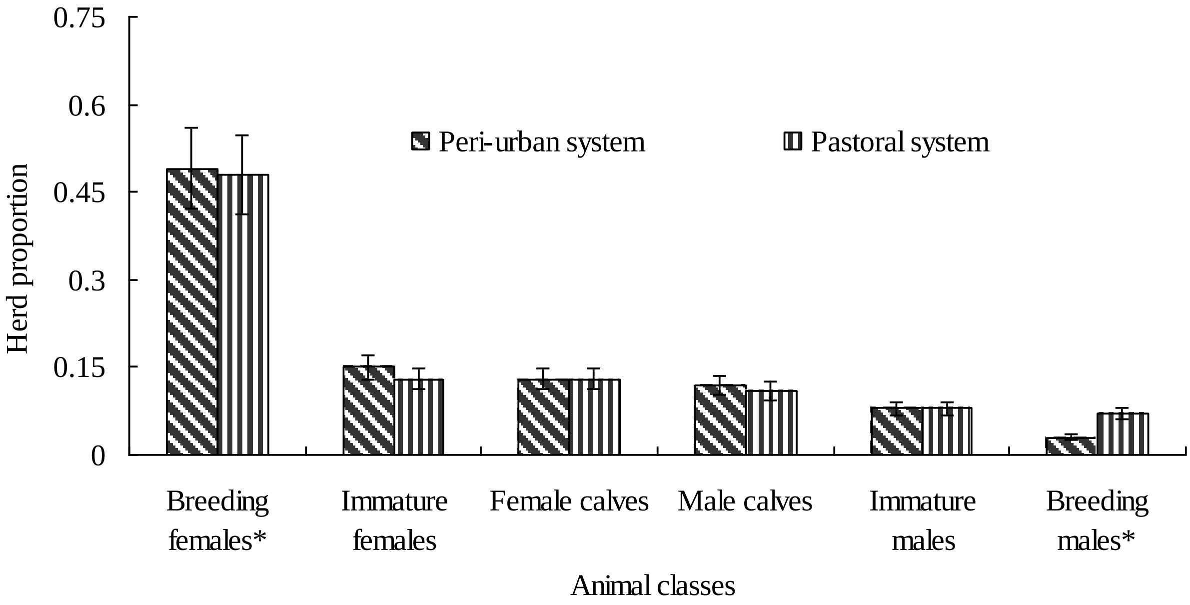

Figure 3.6: Camel herd structures in peri-urban and pastoral systems in Isiolo County, northern Kenya (*=$P<0.05$).

3.3.4 Camel production constraints and coping strategies

The major constraints to Isiolo peri-urban camel production ranked in order of importance by stakeholders in an FGD are: camel diseases, inadequate feed resources and milk spoilage (Table 3.2). The camel diseases mentioned frequently are trypanosomosis and haemorrhagic septicaemia (Table 3.3). Trypanosomosis is of equal concern in both systems while haemorrhagic septicaemia is of more concern in peri-urban than in pastoral herds. The frequently used management practice for camel diseases is use of traditional knowledge treatments and sometimes self prescribed and administered veterinary drugs. In the opinion of stakeholders, non veterinary intervention is common because there is inadequate veterinary service. In addition, most veterinarians in the County are less conversant with camel diseases and therefore not able to provide appropriate and reliable clinical services required.

Table 3.2: Major constraints facing camel producers in Isiolo County of northern Kenya ranked in order of importance and mitigation strategies used.

Rank	Problem/constraint	Coping strategies
First	Camel diseases	• Frequent use of traditional treatments with occasional use of self prescribed and administered veterinary drugs. • Occasional disease diagnosis, through blood sample analysis, done in distant laboratories (e.g. Nairobi). • Occasional vaccinations. • Use of community-based animal health workers (CAHWs), due to limited animal health service providers.
Second	Inadequate feed resources	• Herd splitting (non-lactating camels taken to distant pastures – *forra* herds). • Feeding camels on *Euphorbia tirucalli* plant. • Providing security to enable the *forra* herds exploit distant pastures.
Third	Milk spoilage	• Boiling of overnight milk. • Use of overnight cooling facilities only available in Isiolo town. • Washing of plastic containers with hot water. • Use of metallic cans by few producers.

Table 3.3: Important camel diseases mentioned in pastoral and peri-urban camel production systems in Isiolo County, northern Kenya.

Disease name (Boran/Somali)	Peri-urban system (n=60) (%)	Pastoral system (n=70) (%)
Trypanosomosis (*Dukan/Gandi*)	30.0	30.5
Haemorrhagic septicaemia (*Khandich/*)	21.4	11.1
Anthrax (*Chit/Kut*)	-	11.0
Mange (Mites, Scabies) (*Chito/A'ddo*)	7.2	12.1
Pneumonia/Camel cough (*Dugud/Hergeb*)	15.0	12.1
Camel pox (*Bagga/Furuq*)	-	5.6
Paralysis/Brain disease (*Shimbir/Gudan*)	8. 6	-
Skin necrosis (*Dulla*)	3. 9	-
Others minor diseases	13. 9	17.6

Both peri-urban and pastoral camel producers in Isiolo County face feed shortages (Table 3.2) and the ranked severity is higher ($P<0.001$) in the peri-urban system (Figure 3.7) during dry period. The wet season usually occurs from March through May and November to December. Dry season is experienced from January to February and June through October while drought occurs when the expected wet season fails and dry period is prolonged. The strategies commonly used to mitigate impacts of feed and water shortage during drought in both production systems are sending camels, especially dry herds, to "*forra*" (distant pastures) and prolonging the daily grazing hours. Feeding of *Euphorbia tirucalli* which is non conventional camel forage is a unique mitigation strategy adopted in the peri-urban system.

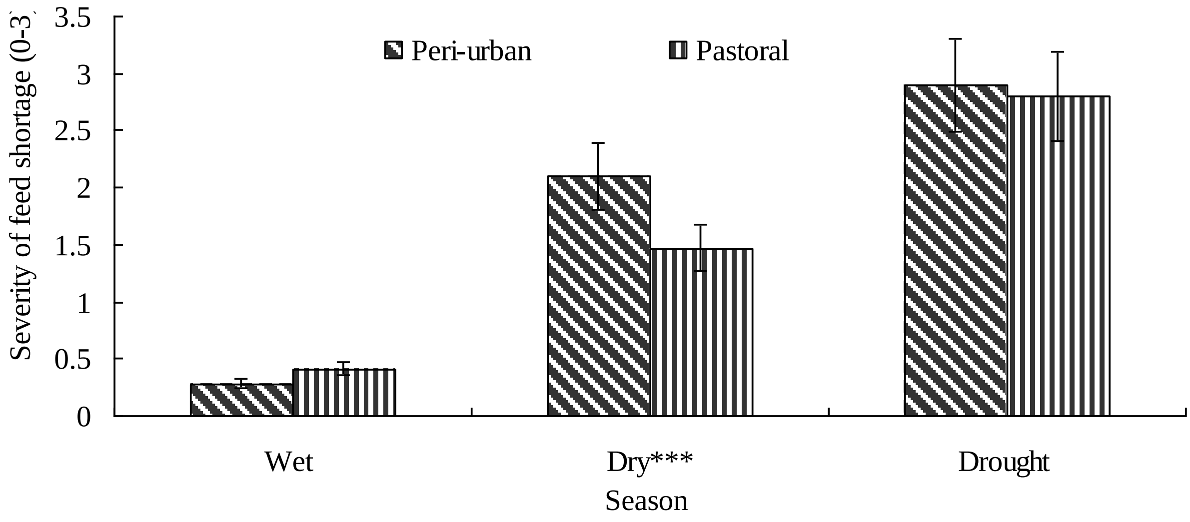

Figure 3.7: Severity of feed shortage experienced in different seasons in pastoral and peri-urban systems in Isiolo County, northern Kenya (***=P<0.001).

While browse forages are of equal importance in both peri-urban and pastoral systems (Figure 3.8), grasses and *Euphorbia tirucalli* (used as live fence) gain more (P<0.05) importance in peri-urban than in pastoral system, pointing to pressure on feed resource base in the peri-urban system. The mitigation strategies are in response to a decline in nutritive value of browse forages (manifested through decrease in crude protein and an increase in crude fibre) (Table 3.4), to support milk yield.

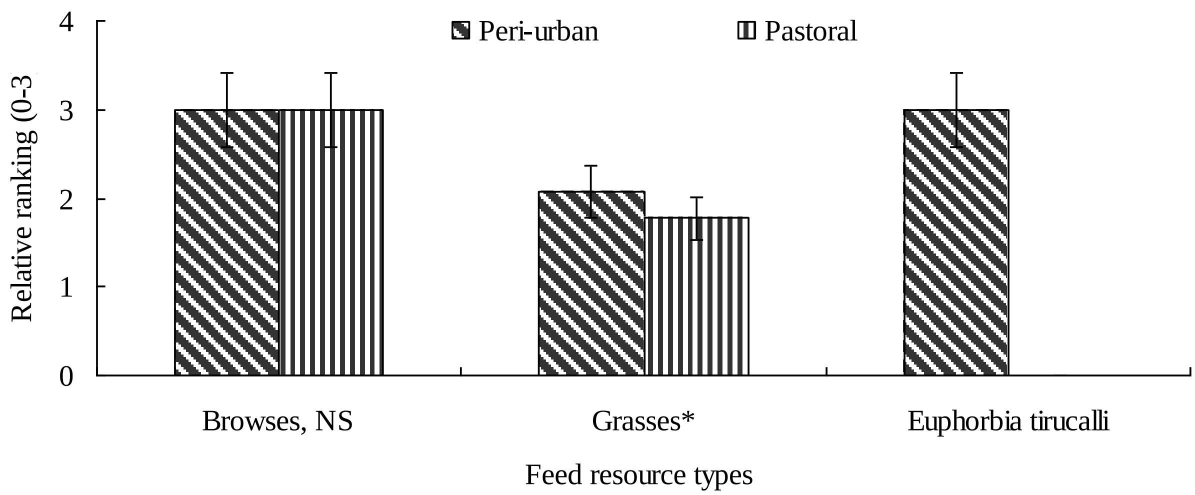

Figure 3.8: Relative importance of camel feed resource types in peri-urban and pastoral systems in Isiolo County, northern Kenya (*=P<0.05; NS – not significant).

Table 3.4: Seasonal changes in the nutritive values (Mean ± SD) of commonly browsed plants by camels during wet and dry seasons in Isiolo peri-urban area, northern Kenya.

Nutrient	Seasons*		% change in the dry season
	Wet (n=15)	Dry (n=15)	
Crude Protein (%)	13.0 ± 6.0	10.5 ± 4.5	- 19.2
Crude Fibre (%)	24.2 ± 8.8	31.3 ± 11.3	+ 29.3
Ash (%)	15.2 ± 8.7	15.2 ± 7.6	0

***The mean nutritive values were obtained from 15 commonly browsed forages collected in the wet and dry seasons.

Relative to wet season, reduction in milk offtake reaches 33% during dry season and 55% when dry season progresses to a drought and consequently, the volume of milk sold is about 36% less during dry season and 60% less when drought is more severe (Table 3.5).

Table 3.5: Seasonal milk offtake (litres/herd/day) and the average quantities sold (litres/herd/day) in different seasons by producers in Isiolo peri-urban area, northern Kenya.

Season	Milk offtake			Milk sold		
	Mean	SD	% decline	Mean	SD	% decline
Wet (n=60)	27.4^{a}	23.7		22.2^{a}	22.9	
Dry (n=60)	$18.4^{b,c}$	15.8	33	$14.2^{b,c}$	14.8	36
Drought (n=60)	12.4^{c}	10.5	55	8.8^{c}	9.8	60

NB: Means with the same letter superscripts within a column are not significantly different (P>0.05).

Though camels experience effects of the drought, their survival is better than other livestock (Table 3.6). In the 2006 drought, there was 3.3% overall herd mortality for camels compared (P<0.05) to 22.1% for goats, 29.4% for sheep and 54.3% for cattle. This indicates high level adaptability to feed and water stresses associated with changing climatic conditions.

Table 3.6: Comparative survival (%) for different livestock species (during the 2006 drought) in Isiolo peri-urban area, northern Kenya.

	Camels	Goats	sheep	Cattle
Sample (n)	2,843	2,480	3,087	2,311
Survival (%)	96.7	77.9	70.6	45.7

Milk spoilage ranks the third most important challenge to camel stakeholders in Isiolo County, especially to producers and traders of milk in the peri-urban system (Table 3.2). Adequate clean water to enhance milking hygiene and milk handling was often lacking, yet plastic containers were commonly used for milk storage and transportation from herds to markets. These types of containers were not easy to clean and therefore cause milk spoilage, even when washed with hot water. Widespread use of overnight cooling facilities in production area is limited by lack of electricity. Thus, only a few individuals with vehicles were able to transport evening milk to Isiolo town where there is electricity.

3.4 Discussion

Two cross sectional surveys were conducted in February 2007 to provide better understanding of the characteristics of an emerging peri-urban camel production system in arid northern Kenya. In addition a focus group discussion of camel stakeholders was organized to complement information from the surveys. Further, laboratory analyses of camel forages provided information on seasonal fluctuation of camel forage quality (Table 3.4). These mix of research methodologies provided empirical evidence for objectively informing development agencies of appropriate interventions for sustaining market-oriented camel production in the ASALs. The ability of camels to survive severe drought periods better (Table 3.6) than other livestock species is a unique attribute attracting development attention with a view to developing markets for camel products and also strengthening processes that add value to the products (LPP, LIFE Network, IUCN-WISP and FAO, 2010).

3.4.1 Importance of camels as a livelihood source

This study provides evidence that camels remain primary source of livelihoods even as pastoralists' transition to semi-sedentary urban lifestyle and milk is the key product. The relative importance attached to camels in both peri-urban and pastoral production systems as a livelihood source (Figure 3.2) is in agreement with previous reports (Yagil, 1986; Stiles, 1987; Guliye et al., 2007). The importance of camels may be attributed to their ability to survive the harsh environmental conditions in ASALs (Yagil, 1985; Rutagwenda et al., 1989; Schwartz, 1992a; Guliye et al., 2007), while providing food by way of milk and meat. The camel plays varied roles in the pastoral and peri-urban production systems of Isiolo County (Figure 3.3). In the peri-urban system, the sale of camel milk is an important economic activity, attributable to the prospect of better returns arising from the increasing demand for camel milk in urban markets like Nairobi. This makes camel keeping a better livelihood source in the peri-urban production system of Isiolo compared to the pastoral system. Therefore strategies that enable increased milk productivity of camels in the peri-urban system will be priority intervention for sustaining market-oriented camel production in the ASALs. Increased milk productivity would contribute to generation of income for the poor while sustaining the camel as a biodiversity genetic resource even under increasing sedentarisation processes of pastoral communities. Generation of household income is a contribution towards attaining Millennium Development Goal one (MDG) of reducing poverty, whereas sustaining the camel as a biodiversity genetic resource contributes to attaining of MDG seven of reducing biodiversity loss.

3.4.2 Emergence of Isiolo peri-urban camel production system

In the last two or three decades, there has been an emerging trend in northern Kenya where camels are reared within the peri-urban areas of towns like Isiolo (Farah et al., 2004a; Onjoro, 2004; Guliye et al., 2007). The emergence of Isiolo peri-urban camel production may have begun in the early 1990s (Figure 3.2), in response to market demands for camel milk and has rapidly increased since then. Consequently, there has been an increase in the number of peri-urban camel producers around Isiolo, which could have attracted camel milk traders transporting milk to the Nairobi market since 1993 (Figure 3.5). Three factors may have contributed to the emergence of market-oriented peri-urban camel milk production around Isiolo. Firstly, there may have been progressive sedentarization of pastoral communities with a camel keeping background in and around Isiolo town since 1972. Secondly, the emergence of a niche market for camel milk in Nairobi's Eastleigh area following the influx of a large Somali community with strong tradition of camel milk consumption. The influx of the Somalis was a result of the collapse of the neighbouring Somali government in 1991 and the subsequent instability that followed. Therefore, the growth of Nairobi urban niche market for camel milk represented strategic market development based on an emerging new market for an existing product. This niche market is also being exploited further through marketing strategies involving exploitation of camel milk as a product with health attributes resulting in brands like "vital camel milk'' which is sold at premium price (KSh. 300 per litre Vs KSh. 30 in Isiolo) in Nairobi up markets.

Thirdly, the presence of a reliable (tarmac) road and daily means of public transport (i.e. buses) for transporting milk from Isiolo town to the main camel milk market in Nairobi. A priority intervention would be to invest in milk processing plant at Isiolo to spur further development of the camel milk value.

The decline in the number of camel milk traders between 1999 and 2001 (Figure 3.5) is attributable to ethnic conflicts in Isiolo area. Consequently, many camel producers moved away from the peri-urban area until relative peace returned. Peace and stability is therefore essential for sustaining market-oriented camel milk production in the ASALs. This also applies to other areas with emerging market oriented peri-urban camel milk production, such as Somalia (Herren, 1990; Farah et al., 2007), Ethiopia (Mehari et al., 2007a; Seifu, 2007) and Djibouti, Mauritania, Morocco and Sudan (Wilson, 1998). Camels are, therefore, slowly but steadily gaining significance as dairy animals for commercial milk production.

3.4.3 Investment in peri-urban camel production enterprises

This study provides evidence of peri-urban camel production system attracting private investment in purchase of the foundation stock unlike in pastoral system where producers build their herds through traditional inheritance culture of asset accumulation (Table 3.1). There were larger proportion of breeding females (0.55 *vs* 0.48) and fewer breeding males (0.03 vs 0.07) in peri-urban system (Figure 3.6), indicating a priority production objective shift towards milk production. This result agrees with previous studies (Wilson, 1998; Baars, 2000; Dereje and Uden, 2005b; Farah et al., 2007) that reported high proportions of Somali camel herds as being breeding females that produce milk. Enterprises attractive to private investment reflect acceptable levels of profitability for the investor (such as camel milk producers in the peri-urban area). This is good for sustaining growth of the niche urban milk market. Therefore, interventions needed are those that will improve animal productivity, processing of milk, organising farmers and support for development of a value chain beneficial to all stakeholders in the chain. Research is vital to effectively design these proposed interventions. Research has to be combined with training on improving productivity, hygiene milk production, handling and processing to add value and enterprise development.

3.4.4 Camel production constraints and coping strategies

The evidence obtained in this study indicate that camel diseases, inadequate feed resources and milk spoilage are constraints requiring urgent attention if peri-urban camel production system in Isiolo is to continue growing on sustainable path. Trypanosomosis and haemorrhagic septicaemia are perceived major challenges, and in particular haemorrhagic septicaemia in peri-urban system impacts on the ability of the system to rear own heifer replacement stock. Simpkin (1993) observed that there are very few Kenyan veterinary doctors conversant with camel diseases and medication; while some vets have been reported to prescribe drugs which have killed camels (Simpkin, 1993) rather than cured them. To address the weak veterinary service delivery in ASALs, a deliberate policy attention is needed to strengthen the use of community-based animal health workers (CAHWs), who are readily accessible to camel producers, in animal health service delivery and to appropriately integrate their activities into the formal animal health delivery system. A recent study (Swai and Masaaza, 2012) revealed that if adequately trained and supervised, CAHWs are capable and may contribute toward delivering animal health services in underserved (marginal) areas. CAHWs can reduce possible cases of drug misuse and abuse associated with the present practice of self prescribed and administered veterinary drugs. Improved public and private efforts in animal health service delivery are needed in terms of recruitment of qualified personnel and establishment of veterinary diagnostic facilities, strategically within camel producing areas to facilitate rapid identification of diseases.

Though both systems experience pressure on feed resource base during dry and drought periods, the pressure is more ($P<0.001$) severe in peri-urban than in pastoral system, with adverse impacts on milk offtake and milk marketed (Table 3.5). Severity of forage scarcity is greater in peri-urban system (Figure 3.7) where milking herds remain closer to urban market for sale of milk, and they feed on purchased *Euphorbia tirucalli* (Figure 3.8), a succulent evergreen forage planted usually as live fence around homesteads. This feeding practice is a shift from the wider selection of plant species by camels through mobility in the rangelands to feeding on non traditional camel forage and at a fee. Though gaining importance as an alternative feed resource, the nutritive value and possible effects of *Euphorbia tirucalli* feeding on milk and meat products are not known and requires urgent attention.

During drought, feed and water shortage impacts on livestock performance. In the year 2006, ASALs of northern Kenya experienced severe prolonged drought with heavy mortality losses of livestock resulting from feed and water shortages. However, camels had high survival rates relative to ($P<0.05$) other livestock species (Table 3.6), indicating high level adaptability to feed and water stresses associated with climate change. The high level adaptation of camels to effects of changing climate has been explained as developed morphological, behavioural and physiological adaptations (Yagil, 1985; Wilson, 1998; Schwartz, 1992a).

Use of cultivated forages, crop residues and supplementation with commercial feeds is not practiced in camel production systems of Isiolo County, a practice also observed in neighbouring Ethiopia (Baars, 2000). The intervention needed is to supplement with appropriate and affordable camel feeding to mitigate feed shortage in dry and drought periods in order to sustain milk yield for sale and for food.

The problem of milk spoilage is of great concern to camel producers in the peri-urban system because it represents direct economic loss to both producers and camel milk traders. Camel milk traders buy only fresh milk from producers because camel milk consumers prefer fresh and un-fermented milk (Farah et al., 2007; Matofari et al., 2007; Seifu, 2007; Matofari et al., 2013). Fermented camel milk (*sussa*) generally sells at lower price.

Milk spoilage is frequently due to lack of clean water for cleaning udder and utensils, use of plastic jerican containers which are inappropriate for milk hygiene in storage and transportation, and lack of understanding of the principles of clean milk production by camel keepers. These challenges can be overcome through improved water supply in camel keeping areas, educating camel herders on clean milk production and handling. Such interventions will not only reduce post-production losses but also provide safe and quality camel milk to consumers.

3.5. Conclusion

The study demonstrates that camels are primary source of livelihoods for pastoral communities even as they transition to semi-sedentary urban lifestyle and milk is the key product. The key drivers behind the emergence of Isiolo peri-urban camel production system were three: (i) progressive sedentarisation of pastoral communities with strong tradition for consumption of camel milk; (ii) emergence of a niche urban market for camel milk in Nairobi, and (iii) a reliable transport infrastructure linking Isiolo town to the niche market in Nairobi. This peri-urban camel production system is growing rapidly and is attracting private investment, particularly in herd expansion. The rapid growth is however sensitive to disruption in peace and stability. Inadequate feed resource base due to effects of recurrent drought, camel diseases (e.g. trypanosomosis and haemorrhagic septicaemia) and milk spoilage associated with low milk hygiene standards constitute major challenges that hinder the growth of Isiolo peri-urban camel milk value chain. Investment in milk processing plant, feed supplementation that enable increased/sustained milk productivity, maintenance of peace and stability in the area and strengthening community animal health workers are some of the key interventions needed to support the development of the peri-urban camel production system.

CHAPTER FOUR

ASSESSMENT OF MARKETING PRACTICES IN AN EMERGING PERI-URBAN CAMEL PRODUCTION SYSTEM IN ISIOLO COUNTY, KENYA

4.1 Introduction

In arid northern Kenya pastoral camel production is a subsistence based system utilising large mobile herds grazing on vast rangeland pasture resources. There is however recent emergence of peri-urban camel production system (PUCPS) utilising milking herds grazed within proximity to urban market outlets for milk, meat and stock.

The prevailing market-oriented camel production present opportunities for the poor households to enhance their food and income securities (SRA, 2004) in the ASALs of arid northern Kenya where annual income averages US $ 217 to 301 against the national average of US $ 360 (ADF, 2003). In these ASAL areas, viable alternative economic activities are lacking, resulting in high dependency on famine relief assistance. However, presently, little is known about marketing practices of camel milk and stock in the emerging peri-urban system. Such information would be useful for planning and for implementation of targeted camel development programmes. This study aimed to answer the research question: to what extent are camel keepers involved in trading of live camels and camel milk? Evidence obtained on these questions can objectively inform development agencies interested in capacity building to enhance trade in live camels and camel milk to improve livelihoods in the ASALs.

4.2 Materials and Methods

4.2.1 Data source

A detailed description of the study area and survey methodology conducted in the year 2007 is presented in Chapter 3. Only brief additional information is presented here.

Data collected through the cross-sectional surveys was a recall of last 12 months preceding the interview period and was complemented by a focus group discussion involving producers and traders in camels and camel products in Isiolo. Specifically, data was collected on milk marketing and the sales and purchases of live animals in both peri-urban and pastoral systems. Data collected in the surveys captured four classes of camels: heifers (before age at first calving), steers (up to 4 years of age), breeding females and breeding males. Prices and reason for selling and buying were also obtained.

Data collected in focus group discussion mapped milk marketing channels from production to consumption at the terminal market in Nairobi.

4.2.2 Data analysis

The proportions of camels sold and purchased were computed within classes of heifers, steers, breeding females and breeding males. *Chi-square* test was applied to detect any significant differences between pastoral and peri-urban production systems. However, where 50% of the cells have expected counts less than 5, *chi-square* is not a valid test and Fisher's exact test was used. The proportion of animals sold and purchased was the proxy for the extent of market orientation.

The reasons for sale declared for each animal sold were cross-tabulated and frequency computed. The frequency was subjected to chi-square test to detect significant differences between pastoral and peri-urban production systems.

The average price of the animals sold and purchased was computed within each class. The average price was then subjected to t – test to detect significant differences between the pastoral and peri-urban systems.

4.3 Results

4.3.1 Marketing of live camels

The estimates of animals sold and purchased in the pastoral and peri-urban herds are presented in Table 4.1. Compared to pastoral producers, peri-urban producers sold 2.4 times more steer surplus stock (25.8 vs 62.8%) and bought 2.2 times more heifer breeding stock (12.3 vs 27.5%).

Table 4.1: Sales and purchases of different camel classes by camel keepers in pastoral and peri-urban systems in Isiolo County, northern Kenya.

Camel class	Production system	N (Camels)	Sales (%)	Purchases (%)
Heifers	Pastoral	301	5.3	12.3
	Peri-urban	382	2.1	27.5
	Total	683	3.5	20.8
	$\chi2$ – value		5.153*	23.602***
Steers (≤4yrs)	Pastoral	186	25.8	2.7
	Peri-urban	204	62.8	0.7
	Total	390	45.1	1.8
	$\chi2$ – value		53.610***	1.610^{NS}
Breeding females	Pastoral	1,143	2.6	0.3
	Peri-urban	1,217	1.5	0.5
	Total	2,360	2.0	0.4
	$\chi2$ – value		3.882*	0.825^{NS}
Breeding males	Pastoral	156	29.5	1.9
	Peri-urban	82	17.1	0.0
	Total	238	25.2	1.3
	$\chi2$ – value		4.393*	1.597^{NS}

Legend: *=p<0.05; ***=p<0.0001; NS=p>0.05.

The stated reasons for selling different classes of camels in the two production systems are presented in Table 4.2. In both systems, camels were sold mainly for livelihood needs of the households (food, clothing, healthcare, fees) and to raise cash for direct investments and rarely because of disease, poor performance or destocking.

Table 4.2: Frequently mentioned reason(s) for selling different camel classes in pastoral and peri-urban systems in Isiolo County, northern Kenya.

Camel class	Production system	Total Sales (N)	Reasons for selling (%)				
			Livelihood needs	Direct investments	Disease cases	Poor performance	Destocking
Overall	Pastoral	140	65.0	26.4	0.7	7.1	0.7
	Peri-urban	168	67.9	22.0	1.8	6.0	2.4
Heifers	Pastoral	16	8.6	2.9	0.0	0.0	0.0
	Peri-urban	8	4.2	0.0	0.6	0.0	0.0
Steers (≤4yrs)	Pastoral	48	26.4	7.9	0.0	0.0	0.0
	Peri-urban	128	60.1	16.1	0.0	0.0	0.0
Breeding females	Pastoral	30	9.3	7.1	0.7	4.3	0.0
	Peri-urban	18	0.6	3.0	1.2	6.0	0.0
Breeding males	Pastoral	46	20.7	8.6	0.0	2.9	0.7
	Peri-urban	14	3.0	3.0	0.0	0.0	2.4

Tables 4.3 and 4.4 present the mean prices (Ksh) for selling and purchasing different classes of camels in pastoral and peri-urban systems. The mean prices were significantly higher ($p<0.05$) for both sales and purchases in pastoral system than in peri-urban system.

Table 4.3: Mean (± SD) sale price (KSh)a of different classes of camels in pastoral and peri-urban systems in Isiolo County, northern Kenya.

Camel class	Production system		Mean difference	*t – test*
	Pastoral	Peri-urban		*P*–value
Heifers	17,070 ± 10,864	11,200 ± 5,575	5,870	0.282 [NS]
Steers (≤4yrs)	11,138 ± 7,838	10,800 ± 3,082	338	0.835 [NS]
Breeding females	16,738 ± 10,322	13,900 ± 3,814	2,838	0.407 [NS]
Breeding males	20,152 ± 8,148	12,800 ± 4,532	7,352	0.044*

[a]KSh. 69=1US $ at the time of the study (2007). Legend: *p<0.05; NS p>0.05.

Table 4.4: Mean (± SD) purchase price (KSh)a of different classes of camels in pastoral and peri-urban systems in Isiolo County, northern Kenya.

Camel class	Production system		Mean difference	*t – test*
	Pastoral	Peri-urban		*P*–value
Heifers	22,308 ± 16,616	13,022 ± 3,294	9,286	0.013*
Steers (≤4yrs)	9,375 ± 2,428	10,000[b]	625	0.833 [NS]
Breeding females	15,000 ± 1,000	14,000 ± 6,164	1,000	0.797 [NS]

[a]KSh. 69=1US $ at the time of the study (2007). [b]Only 3 males were purchased in peri-urban system for the same price. Legend: *p<0.05; NS p>0.05.

4.3.2 Marketing of camel milk

Under pastoral system, milk production is mainly for subsistence (household) consumption and calf feeding. Discussions with pastoral producers revealed that they would wish to sell milk to get money for other needs but they do not have access to markets easily due to distance and poor road infrastructure. The result presented in Figure 4.1 indicates the marketing channels of camel milk from peri-urban producers in Isiolo to the consumers in Nairobi.

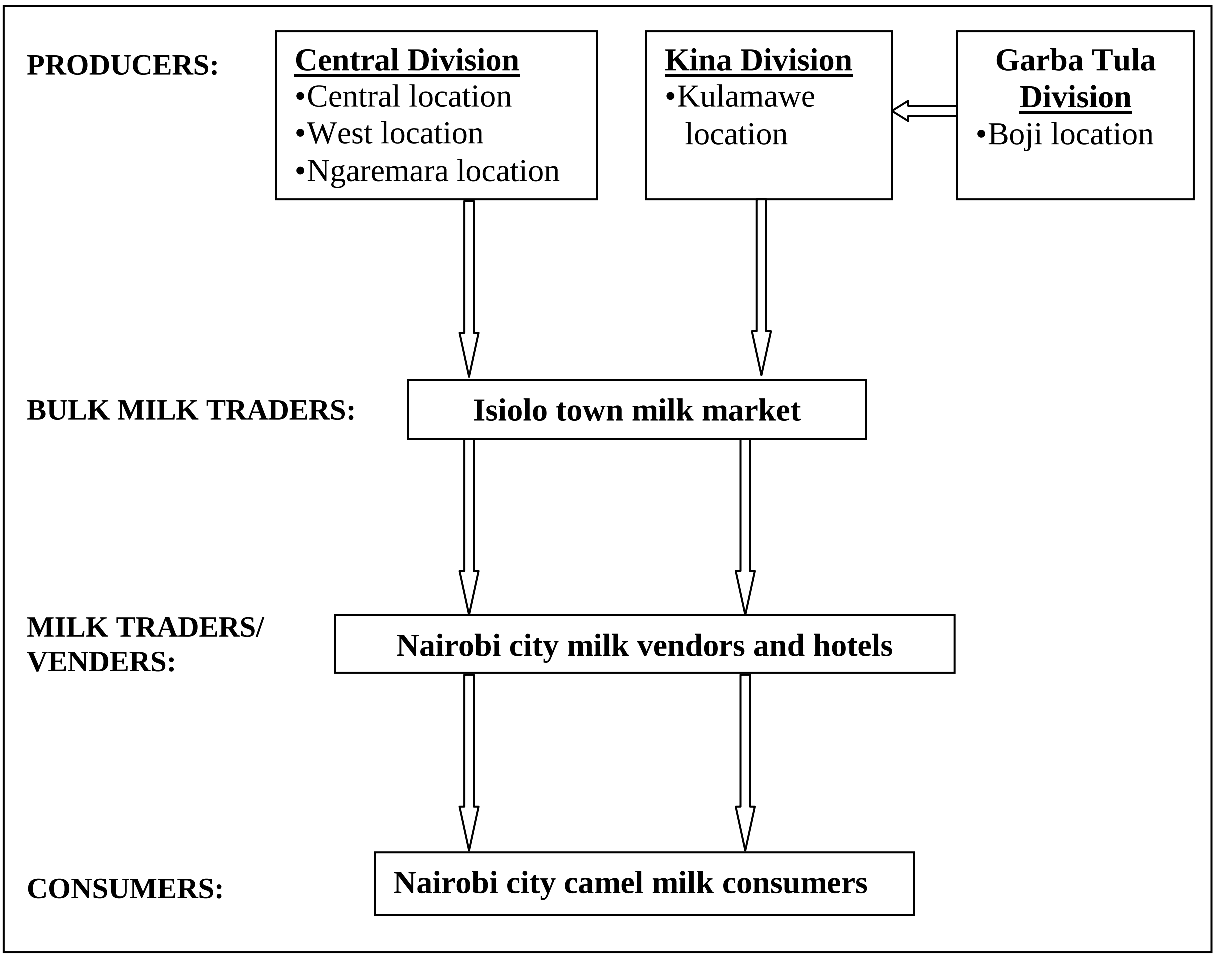

Figure 4.1: Camel milk marketing channels from peri-urban producers in Isiolo to consumers in Nairobi, Kenya.

The bulk of the milk supply to Isiolo town comes from peri-urban herds in Central Division (Figure 4.1), where we have a high concentration of lactating camel herds. Another substantial amount of milk comes from pastoral herds in areas near reliable road network to Isiolo town, such as Kulamawe in Kinna Division and Boji in Garba Tulla Division. The bulk of the milk is transported in non-food grade plastic containers to Nairobi niche market and is traded in raw form by milk traders. The plastic containers are usually difficult to clean and sanitize.

The marketing characteristics of camel milk reaching and leaving Isiolo town market are presented in Table 4.5. The price of camel milk in Isiolo town is about Ksh. 40 (equivalent to US $ 0.4) per litre offered by milk traders who have informal contractual arrangement. Milk from within the peri-urban area is transported over a distance of about 10 km to reach Isiolo town market using donkeys (94.9%), although a few producers (5.1%) with large volumes of milk use four wheel pick-up vehicles. Most (71.2%) milk traders buy milk on informal contractual arrangements with producers, reflecting an organized market.

Table 4.5: Marketing characteristics of camel milk from Isiolo peri-urban area, northern Kenya.

	Mean ± SD	% Herds
Milk price (KSh/litre)[a]	28.7 ± 5.2	
Distance from grazing field to milk market (km)	9.6 ± 5.1	
Milk buyer is frequently a milk trader		100
Milk is transported to Isiolo market using:		
Donkeys		94.9
Vehicles		5.1
Milk payment is through:		
Informal contract arrangement		71.2
Direct cash		28.8

[a]KSh. 69=1US $ at the time of the study (2007).

Figure 4.2 presents results for camel milk quality testing methods used by milk traders in Isiolo town. Most producers and milk traders in both systems (85.7% for pastoral and 100% for peri-urban system) use subjective measurements of taste and colour to determine milk quality and hygiene.

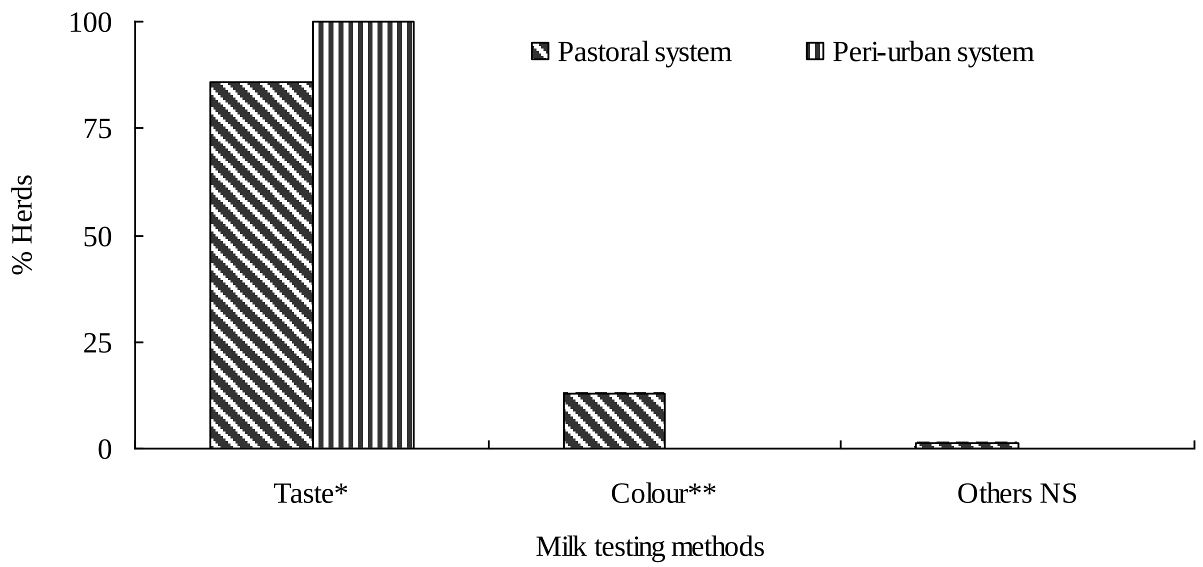

Figure 4.2: Camel milk quality testing methods used by traders in Isiolo County, northern Kenya (*=P<0.05; **=P<0.01).

4.4 Discussion

4.4.1 Market integration of live camels and camel milk

This study provides evidence of market integration of live camels and milk in Isiolo and Nairobi urban markets. Trade in live camels is localized within the country, though export trade to Middle East is known to be lucrative enterprise (Mahmoud, 2010). Local (i.e. in country) trade involves supply of breeding stock from pastoral to peri-urban system focused on milk production.

The main reasons for sale of live animals are to meet livelihood needs and raising cash for other direct investments. Camel prices reportedly vary from 17,000 to 35,000 Kenya shillings (Ksh.) (Kenya Camel Association Reports, 2009) (equivalent to US $ 246 to 507 at the prevailing exchange rate of Ksh. 69=1US $ at the time of the study), depending on a number of factors, including age, body condition and market supply and demand forces. A possible explanation for the significantly higher ($p<0.05$) difference in the mean prices (Tables 4.3 and 4.4) for selling breeding males and buying heifers could be lack of adequate market information. Pastoral producers are usually far from the market, thus, their prices most probably reflect optimism, while, the prices given by peri-urban producers appear to reflect the reality at Isiolo town market, as at the time of this study. It is important to note that at the time of data collection for this study, prices of live camels in northern Kenya was around the values quoted by producers in the peri-urban system (Tables 4.3 and 4.4).

According to Chabari and Njiru (1991), a number of impediments to livestock marketing in northern Kenya include: poor quality roads, lack of reliable market information, livestock rustling and general insecurity, absence of consistent livestock marketing policies, and hence dependency on private traders. Of vital importance is the need to initiate market information flow between the producer areas and terminal markets to minimize exploitation of the producers by traders and middlemen.

Information on camel meat consumption was not collected in this study, but slaughters are almost on daily basis, in major towns like Nairobi, Mombasa, Nanyuki and Nakuru, indicating an increase in formal marketing of live camels. Efforts towards developing an organized marketing channel will not only enhance development of new markets for live camels within the country but also provide link to export markets.

4.4.2 Milk marketing constraints and possible interventions

With increasing sedentarization, camel milk is increasingly commercialized and consumed in urban areas. The price of camel milk in Isiolo town of US $ 0.4 per litre is higher than the US $

0.34 per litre reported by Baars (2000) for producers in neighbouring Eastern Ethiopia. However, the price of milk is not influenced by distance between the production area and terminal market. A recent cross-border study (Mahmoud, 2010) covering Northern Kenya/Southern Ethiopia suggests that the benefits associated with peri-urban camel dairying are enormous. In agreement with the present study, Mahmoud (2010) stated that selling camel milk has proven lucrative and has created new sources of income, particularly for women, who are mostly the buyers and sellers of camel milk.

In agreement with present results, Farah et al., (2004b), identified the main constraints of this emerging milk market as, (i) poor hygienic quality of the commercialized milk, and (ii) lack of milk processing technologies to improve shelf life and expand production and sales. The observed use of taste and colour as hygiene and quality control measure (Figure 4.2) is subjective and therefore not adequate for ensuring proper hygiene and quality of camel milk. According to Wangoh and Farah (2004), two sets of standard milk quality control tests widely used for cow’s milk testing can be used for camel’s milk as well to assess the freshness and hygienic quality of milk and the other which measures the milk composition and, thereby, helps to detect fraudulent adulterations. These same authors, however, state that the interpretation of some of the tests on camel’s milk should be done with caution. There is need, therefore, to develop and adopt scientific camel milk hygiene and quality testing practices.

Like in most other pastoral communities, camel milk is believed to be medicinal and is usually consumed raw without any heat treatment. Camel milk traders in the study area buy only fresh milk from producers. In agreement with previous studies (Farah et al., 2007; Seifu, 2007), the reason for this is because most camel milk consumers prefer fresh and unfermented camel milk. However, Akweya et al (2010b) states that camels are usually milked in poor sanitary conditions, with all the predisposing factors to diseases such as mastitis that include dust, flies and scarce water resources. In addition, several studies (Akweya et al., 2010b; Meile, 2010; Wanjohi et al., 2010) have demonstrated the presence of common milk pathogens, mostly *Staphylococcus aureus*. Milk generally contains high levels of micro-organisms. Farah et al (2004b) reported that drinking untreated camel milk can cause gastric distress and more serious zoonotic diseases such as brucellosis, tuberculosis or typhoid. Consequently, there is health risks associated with the consumption of raw milk which could limit wider marketing opportunities among the non-camel keeping communities. To enhance marketing of camel milk, the quality and safety of the products for consumers needs to be seriously addressed. Some of the key constraints or challenges that need to be addressed revolve around the use of plastic jerican containers which are inappropriate for milk storage and transportation from herds to markets, lack of clean water for milking, lack of understanding of the principles of clean milk production by camel keepers, and lack of overnight milk cooling facilities.

Development agencies interested in supporting rural livelihoods using the camel as a resource could assist in overcoming these challenges through replacement of plastic with quality steel (aluminum) containers for storage and transporting milk, improved water supply in camel keeping areas, educating camel herders on clean milking and handling practice, and provision of overnight milk cooling facilities. Such interventions will not only reduce post-production losses but also provide safe and quality camel milk to consumers. The income from camel milk marketing can also be enhanced through sale of value added milk products instead of selling unprocessed raw milk.

4.5 Conclusion

Compared to pastoral system, PUCPS exhibits greater market-oriented production in disposing surplus stock, purchasing breeding stock and selling more milk to market. However, poor milk hygiene and subjective milk quality testing could be barriers to accessing expanded niche urban markets. To enhance marketing of camel milk, the quality and safety of the products for consumers needs to be seriously addressed through investment in milk processing plant at Isiolo to pasteurize and add value for the growing niche urban town markets in Kenya. In addition, there is need to develop and adopt scientific camel milk hygiene and quality testing methods which would be introduced through cooperatives and organized producer groups.

CHAPTER FIVE

EVALUATION OF NUTRITIVE VALUES OF COMMON CAMEL BROWSE FORAGES IN ISIOLO PERI-URBAN AREA, NORTHERN KENYA

5.1 Introduction

Camels under pastoral systems have mixed feeding behaviour and their diets can be extraordinarily varied (Dereje and Uden, 2005b). They select vegetation of fairly good quality which contributes to reducing the risks of nutritional deficiencies. However, there is an emerging peri-urban system where camel foraging is restricted within the vicinity of urban market outlets in which pressure on feed resource base is high especially during dry and drought seasons.

The peri-urban system does not present all-year-round availability and choice of browse forages. The seasonal fluctuation in quantity and nutritional quality of browse forages substantially depress milk offtake, which is a priority production objective in peri-urban system, by 33 to 55% (chapter 3), limiting the source of income and food for the households. This seasonality in feed resource supply and subsequent fluctuation in milk yield would disrupt further development of the emerging camel milk market. Knowledge of the quality of forages commonly browsed by camels in peri-urban areas would improve the understanding of the present status of camel feeding, particularly the extent of nutritional constraints from nutrient analysis.

This chapter aimed to assess the extent of nutritional seasonal variation in camel browse forages in the peri-urban systems in arid northern Kenya. The empirical evidence generated can objectively inform design of supplementary feeding strategies to sustain milk supply for food and income to the households.

5.2 Materials and Methods

5.2.1 Identification, collection and processing of forages

The identification of the camel forages was achieved by asking the survey respondents to list the plants (using local names) found in the areas which were commonly browsed by camels during wet and dry seasons, respectively. The survey was conducted as described in Chapter Three (3), section 3.2. It has been recognized that most camel herders have good knowledge of plants eaten by their livestock (Farah et al., 2004a; Onjoro, 2004; Kuria et al., 2005). Experienced camel herders identified the forages by their local names which were then matched to scientific names, by a range of scientist (Evans et al., 1995; Maundu and Tengnas, 2005). From the data obtained, the most commonly browsed plants were ranked. Out of the ranked plants, the top ten were identified for each season and sampled for analyses. Forage sample collection involved hand clipping of edible parts (young twigs/shoots, leaves, flowers and pods, where present) usually selected by the camels. Samples were collected from different plants of the same species in the area in order to obtain representative samples. The samples were air-dried in the field, then oven-dried in the laboratory at 105ºC, milled using a hammer mill to pass through a 2 mm sieve and stored in air-tight bottles for analysis.

5.2.2 Chemical analysis of forages commonly browsed by camels

Forage samples were subjected to proximate analysis (DM, CP, CF, Ash) according to AOAC (1995); and fibre component (NDF and ADF) was analyzed according to the procedure of Van Soest et al (1991). Mineral concentrations were analyzed for major elements (calcium, phosphorus, potassium, sodium, magnesium) and trace elements (cobalt, copper, zinc and iron) using Atomic Absorption Spectrophotometer (AAS) (Model S-11 manufactured by Thermo Jarrel Ash Corporation, USA). The energy content (MJ/Kg DM) was determined using bomb calorimeter, e2k model (www.cal2k.com). In addition to determining chemical composition, evaluation of nutritive value of forages was achieved through digestibility studies. This procedure was employed because forage quality is influenced by the amount of dry matter ingested and its digestibility. For example, dry matter digestibility is positively correlated to CP content and negatively correlated to CF, NDF and ADF.

Consequently, *in vitro* dry matter digestibility (IVDMD) was carried out using modified Tilley and Terry (1963) digestion technique as described by Jones and Barnes (1996) (Plate 2). To achieve this, rumen fluid was obtained from two slaughtered camel steers fed on mixed natural range vegetation. Immediately after slaughter, the stomach compartment equivalent of rumen (in true ruminant) was slit and digesta squeezed first through ordinary kitchen sieve, followed by filtering through cheese cloth and the fluid stored in a thermos flask. This was repeated with the second animal and the two samples were then mixed in equal proportions. The thermos flask containing the fluid was flashed with CO_2, from a cylinder carried to the site of slaughter, prior to closing and taking immediately to the laboratory. Frequent CO_2 flashing into the fluid was maintained for purposes of achieving anaerobic conditions. In the laboratory, one part of rumen fluid was mixed with four parts of McDougalls' artificial saliva, prepared according to McDougall (1948). The mixture was flashed with CO_2 gas and thoroughly stirred. Fifty ml of the mixture was dispensed into each of duplicate digestion tubes with 0.5 g of feed samples. Thereafter, the tubes were flashed with CO_2 and securely stoppered with a one-way gas-release valve. Two control tubes (blanks with fluid mixture only) with no feed samples were included. The tubes were then incubated at 39ºC for 72 h. Separate duplicate samples of the feeds were weighed for oven-drying at 100ºC for DM determination. During incubation, the

Plate 2: The researcher running in vitro dry matter digestibility (IVDMD) experiment at Egerton University.

tubes were gently swirled 3 times a day. After 72 h, the tubes were centrifuged at 2500g for 10min, the supernatant liquid poured off and 50 ml of a freshly prepared pepsin solution (4 g pepsin (1:1000) dissolved in one litre of 0.1N hydrochloric acid) added. The tubes were again incubated at 39ºC for another 24 h while swirling 3 times a day. The digested mixtures (samples) were filtered through pre-weighed sintered glass crucibles of porosity 1. The glass crucibles with the residue were dried at 100ºC for 24 h and then weighed to determine weight of the residue.

Further, a combined nutritive quality index score was computed to rank the forages. To achieve this, nutrients of high requirement for milk production (energy and protein) and a nutritive measure indicator important in utilization of forages (digestibility, i.e. IVDMD) were assigned weighting factors presented in Table 5.1 below. The weighting factors were then multiplied by the corresponding forage nutrient content values reported in Tables 5.2a and 5.2b, then the resultant figures summed up to give a combined nutritive quality index score. This index values computed reflect the nutritive value of the respective forage species.

Table 5.1: Weighting factors used to compute the combined nutritive quality index score

Nutrient requirement	Energy	CP	IVDMD
Rank assigned as weighting factor	1.0	0.8	0.8

CP=Crude Protein; IVDMD=*In Vitro* Dry Matter Digestibility.

5.3 Results

5.3.1 Forages commonly browsed by camels and their nutritive values

The top ten forage species (ranked by pastoralists' based on preference of the camels') commonly browsed by camels in Isiolo peri-urban area during wet and dry seasons with their proximate composition (DM, CP, CF, Ash) and fibre (ADF, NDF) contents are presented in Tables 5.2a and 5.2b, respectively. The results reflect diversity of camel's diet, which comprise of trees, shrubs and dwarf shrubs. Respondents indicated that forage species *Salvadora persica, Blepharis linariifolia* and *Maerua angolensis* were browsed during both wet and dry seasons.

The chemical composition results showed marked seasonal variations in the average nutritive values, with wet season more superior than dry season for CP (15.70% vs 9.86%), CF (23.22% vs 32.57%) and for NDF (44.38% vs 53.15%). The results show a decrease in CP by as much as 37.20% from wet to dry season, while CF, NDF and ADF increased by 28.71%, 16.50% and 11.41%, respectively. This provides evidence of seasonal fluctuations in nutritive values of browses, with quality declining in dry season.

Table 5.2a: Nutrient composition of the top ten forages commonly browsed by camels in Isiolo peri-urban area of northern Kenya during wet season.

Forage species[a]		DM	CP	CF	Ash	NDF	ADF
Scientific name	Local name (B/S)	%	%	%	%	%	%
Cordia sinensis[1,2]	*Mader/ Marer*	91.54	11.56	23.47	14.92	54.99	52.28
Grewia tenax[2]	*Deeka/Deeka*	92.26	18.20	21.73	13.05	41.41	29.48
Salvadora persica[1,2]	*Aadde/ Aadhey*	88.24	19.08	15.58	31.20	33.03	24.53
Blepharis linariifolia[4]	*Baarat/ Jimaarouk*	92.04	19.22	28.62	13.21	51.82	40.39
Acacia mellifera[1,2]	*Sabans/ Bil'il*	89.63	24.49	16.40	7.89	39.33	27.02
Grewia villosa[2]	*Ogomdi/ Kobbish*	91.70	9.16	24.02	19.63	40.84	36.60
Lycium europaeum[2]	*Furs/*	89.73	19.82	15.83	27.00	33.36	30.36
Cadaba farinosa[2]	*Tutch/ Tukh*	90.23	15.98	26.74	7.88	45.40	31.47
Grewia trichocarpa[2]	*Arores/*	91.50	7.51	24.40	10.69	48.89	35.66
Maerua angolensis[1,2]	*Qalqach/ Qalanqal*	92.65	11.95	35.39	6.46	54.68	40.83
	Overall mean	90.95	15.70	23.22	15.19	44.38	34.86
	Range	88.24-92.65	7.51-24.49	15.58-35.39	6.46-31.20	33.03-54.99	24.53-52.28

[a]=Column listing based on the most to the least frequency of use; [1]=Tree; [2]=Shrub; [3]=Dwarf shrub; [4]=Herb; B=Borana; S=Somali; DM=Dry Matter; CP=Crude Protein; CF=Crude Fibre; NDF=Neutral Detergent Fibre; ADF=Acid Detergent Fibre. All analyses were performed in duplicate samples.

Table 5.2b: Nutrient composition of the top ten forages commonly browsed by camels in Isiolo peri-urban area of northern Kenya during dry season.

Forage species[a]		DM	CP	CF	Ash	NDF	ADF
Scientific name	Local name (B/S)	%	%	%	%	%	%
Maerua angolensis[1,2]	*Qalqach/ Qalanqal*	93.61	10.09	47.71	8.76	66.45	43.00
Salvadora persica[1,2]	*Aadde/ Aadhey*	90.13	15.68	19.98	34.25	45.39	31.15
Duosperma eremophilum[3]	*/Sarim*	90.23	6.64	22.18	29.00	34.03	32.86
Euphorbia tirucalli[1,2]	*Anno/ Danna*	91.65	4.47	35.38	12.71	49.68	47.06
Blepharis linariifolia[4]	*Baarat/ Jimaarouk*	94.83	5.68	33.13	22.97	64.94	44.21
Indigofera spinosa[3]	*Qil'tiipe/ Me'eretil*	94.31	7.06	46.86	10.74	67.04	54.37
Dobera glabra[1]	*Garse/ Garas*	93.65	9.70	29.33	20.47	53.71	30.64
Barleria proxima[3]	*Maadeeka/ Odhatol*	92.34	13.83	36.00	14.86	58.33	43.09
Indigofera cliffordiana[3,4]	*Agaggaro/ Darqa*	92.72	16.18	40.28	9.07	62.20	51.29
Lorianthus spp.[2]	*Tuqto/ Qathey*	92.85	9.30	14.82	12.65	29.70	15.81
	Overall mean	92.63	9.86	32.57	17.55	53.15	39.35
	Range	90.13-94.83	4.47-16.18	14.82-47.71	8.76-34.25	29.70-67.04	15.81-54.37

[a]=Column listing based on the most to the least frequency of use; [1]=Tree; [2]=Shrub; [3]=Dwarf shrub; [4]=Herb; B=Borana; S=Somali; DM=Dry Matter; CP=Crude Protein; CF=Crude Fibre; NDF=Neutral Detergent Fibre; ADF=Acid Detergent Fibre. All analyses were performed in duplicate samples.

Table 5.3 presents results for gross energy and *in vitro* dry matter digestibility (IVDMD) for the forages during wet and dry seasons. The results show only marginal seasonal variations with wet season more superior than dry season for energy content (15.45% vs 14.65%) and for IVDMD (68% vs 63%).

Table 5.4 presents results of pastoralists' ranking and combined nutritive quality index (CNQI) score ranking for the forages during wet and dry seasons. The index scores with their corresponding rank, in which the values reflect the nutritive value of the respective forage species, were compared against pastoralists' ranking, reflected through animal preference. The comparison aimed to establish the existence of any correlation between the two sets of ranking. The results revealed some correlation (for the top two wet season forages and top three dry season forages). Due to the progressive decline in tree browses, there is need to identify plants for propagation in tree nurseries. Consequently, the aim of the study was to establish the nutritive potential of using the forages for camel feeding with the intention of recommending their use in afforestation programmes. In addition, the nutritive quality index will provide future researchers interested in detailed camel feeding experiments with base line information on the nutritive value of some important camel forage species found in the study area. The computed nutritive quality index score was not really meant to identify the best forages with a view to recommend their harvesting as a way of dry season supplementary intervention. This is because, unlike cultivated fodder plants, most of these forage browse species have not been "domesticated". In addition, some of them, such as Acacias, have very small leaves which are difficult to harvest.

Table 5.3: Energy content (MJ/kg DM) and in vitro DM digestibility (IVDMD) of the top ten forages commonly browsed by camels in Isiolo peri-urban area of northern Kenya during wet and dry seasons.

Wet season			Dry season		
Forage species	Energy content (MJ/kg DM)*	IVDMD (%)*	Forage species	Energy content (MJ/kg DM)*	IVDMD (%)*
Blepharis linariifolia	15.22(8)	0.70(5)	*Indigofera cliffordiana*	16.05(4)	0.63(5)
Acacia mellifera	17.04(2)	0.83(1)	*Maerua angolensis*	17.69(1)	0.54(6)
Maerua angolensis	16.83(3)	0.55(8)	*Barleria proxima*	14.82(6)	0.53(7)
Grewia tenax	16.52(4)	0.75(4)	*Indigofera spinosa*	16.17(2)	0.50(8)
Cadaba farinosa	17.22(1)	0.70(5)	*Blepharis linariifolia*	13.61(8)	0.42(9)
Cordia sinensis	15.43(7)	0.50(9)	*Salvadora persica*	11.36(10)	0.82(1)
Grewia trichocarpa	16.25(5)	0.56(7)	*Dobera glabra*	13.79(7)	0.66(4)
Lycium europaeum	13.20(9)	0.81(2)	*Euphorbia tirucalli*	16.12(3)	0.72(3)
Grewia villosa	15.93(6)	0.64(6)	*Lorianthus spp.*	15.14(5)	0.72(3)
Salvadora pérsica	10.89(10)	0.79(3)	*Duosperma eremophilum*	11.74(9)	0.74(2)
Overall mean	15.45	0.68	Overall mean	14.65	0.63
Range	10.89-17.22	0.50-0.83	Range	11.36-17.69	0.42-0.82

*Figures in brackets () indicate the rank position, based on the nutrient value.

Table 5.4: Pastoralists' ranking and combined nutritive quality index score ranking of the top ten forages commonly browsed by camels in Isiolo peri-urban area of northern Kenya, during wet and dry seasons.

Wet season				Dry season			
Forage species	Pastoralists' ranking	Combined nutritive quality index score		Forage species	Pastoralists' ranking	Combined nutritive quality index score	
		*Index score	Rank			*Index score	Rank
Blepharis linariifolia	1	31.16	3	*Indigofera cliffordiana*	1	29.50	1
Acacia mellifera	2	37.30	1	*Maerua angolensis*	2	26.19	3
Maerua angolensis	3	26.83	6	*Barleria proxima*	3	26.31	2
Grewia tenax	4	31.68	2	*Indigofera spinosa*	4	22.22	6
Cadaba farinosa	5	30.56	4	*Blepharis linariifolia*	5	18.49	9
Cordia sinensis	6	25.08	8	*Salvadora persica*	6	24.56	4
Grewia trichocarpa	7	22.71	10	*Dobera glabra*	7	22.08	7
Lycium europaeum	8	29.70	5	*Euphorbia tirucalli*	8	20.27	8
Grewia villosa	9	23.77	9	*Lorianthus spp.*	9	23.16	5
Salvadora pérsica	10	26.79	7	*Duosperma eremophilum*	10	17.64	10

*Index score obtained by: (MJ*1.0) + (CP*0.8) + (IVDMD*0.8). MJ = Mega joule; CP = Crude Protein; IVDMD = *In Vitro* Dry Matter Digestibility.

The mineral content of the forages during wet and dry seasons is given in Tables 5.5a and 5.5b, respectively. For most of the minerals (both macro and trace), the results show clear interspecies differences both within and between seasons. The ranges of different mineral concentration of the forages show wide variations. However, based on the results of the three forage species (*Salvadora persica, Blepharis linariifolia* and *Maerua angolensis*) browsed during both wet and dry seasons, there was no clear trend in specific mineral element concentration in forages between seasons.

In a number of samples, the concentration levels were undetectable. For example, cobalt concentration was not detectable in 6 of the 10 wet season samples. During the dry season, the mineral concentration was too low to be detected in 8 of the 10 samples. Similarly, copper levels could not be detected in 2 and 4 of the 10 samples for wet and dry seasons, respectively. Phosphorus could not be detected in 1 of the 10 dry season samples. Under the circumstances, it was considered inappropriate to calculate the overall mean concentration of the different minerals in the forage species during the different seasons.

Table 5.5a: Mineral content (gm/kg DM) of the ten most commonly foraged browses by camels in Isiolo peri-urban area of northern Kenya during wet season.

Forage species	Ca	P	K	Na	Mg	Co	Cu	Zn	Fe
Cordia sinensis	$2.0x10^{-2}$	$7.7x10^{-2}$	$3.1x10^{-2}$	$3.4x10^{-2}$	$6.0x10^{-3}$	0.0	$4.0x10^{-4}$	$4.0x10^{-4}$	$8.2x10^{-3}$
Grewia tenax	$5.4x10^{-2}$	$4.7x10^{-1}$	$4.4x10^{-2}$	$1.9x10^{-2}$	$6.4x10^{-3}$	0.0	$2.0x10^{-4}$	$2.0x10^{-4}$	$3.8x10^{-3}$
Salvadora pérsica	$6.3x10^{-2}$	$2.8x10^{-1}$	$3.1x10^{-2}$	$9.3x10^{-2}$	$7.2x10^{-3}$	$3.0x10^{-4}$	$2.0x10^{-4}$	$1.0x10^{-4}$	$2.3x10^{-3}$
Blepharis linariifolia	$3.4x10^{-2}$	1.6x10-1	$3.8x10^{-2}$	$1.8x10^{-2}$	$5.5x10^{-3}$	$3.0x10^{-4}$	0.0	$4.0x10^{-4}$	$1.6x10^{-3}$
Acacia mellifera	$1.9x10^{-2}$	$4.4x10^{-1}$	$4.4x10^{-2}$	$1.3x10^{-2}$	$6.6x10^{-3}$	0.0	$2.0x10^{-4}$	$4.0x10^{-4}$	$2.8x10^{-3}$
Grewia villosa	$6.1x10^{-2}$	$2.4x10^{-1}$	$4.1x10^{-2}$	$2.0x10^{-2}$	$7.1x10^{-3}$	$3.0x10^{-4}$	$4.0x10^{-4}$	$3.0x10^{-4}$	$2.2x10^{-3}$
Lycium europaeum	$4.0x10^{-2}$	$2.1x10^{-1}$	$3.4x10^{-2}$	$6.0x10^{-2}$	$6.2x10^{-3}$	0.0	$4.0x10^{-4}$	$2.0x10^{-4}$	$4.5x10^{-3}$
Cadaba farinosa	$2.7x10^{-2}$	$2.6x10^{-1}$	$4.0x10^{-2}$	$1.4x10^{-2}$	$7.5x10^{-3}$	0.0	0.0	$2.0x10^{-4}$	$6.7x10^{-3}$
Grewia trichocarpa	$4.2x10^{-2}$	$3.3x10^{-1}$	$3.6x10^{-2}$	$1.2x10^{-2}$	$4.5x10^{-3}$	$3.0x10^{-4}$	$2.0x10^{-4}$	$2.0x10^{-4}$	$9.8x10^{-3}$
Maerua angolensis	$3.6x10^{-2}$	$2.2x10^{-1}$	$3.5x10^{-2}$	$1.7x10^{-2}$	$8.5x10^{-3}$	0.0	$2.0x10^{-4}$	$1.0x10^{-4}$	$4.3x10^{-3}$
[a]Recommended requirements in diets	3	1-3	2	6-8	$6.0x10^{-1}$	$3.0x10^{-5}$	$1.0x10^{-4}$	$1.0x10^{-2}$	30

[a]Source: Kuria et al., 2004 (Quoting from McDowell, 1985 and NRC, 1989) reporting on recommended requirements in diets while the figures reported here are for individual plants. The units used were gm/kg DM.

Table 5.5b: Mineral content (gm/kg DM) of the ten most commonly foraged browses by camels in Isiolo peri-urban area of northern Kenya during dry season.

Forage species	Ca	P	K	Na	Mg	Co	Cu	Zn	Fe
Maerua angolensis	2.2×10^{-2}	1.4×10^{-1}	4.5×10^{-2}	1.5×10^{-2}	3.8×10^{-3}	0.0	0.0	2.0×10^{-4}	1.1×10^{-3}
Salvadora persica	7.2×10^{-2}	2.9×10^{-1}	2.6×10^{-2}	1.5×10^{-2}	6.1×10^{-3}	0.0	0.0	3.0×10^{-4}	2.2×10^{-3}
Duosperma eremophilum	3.3×10^{-2}	2.4×10^{-1}	3.5×10^{-2}	2.6×10^{-1}	8.6×10^{-3}	0.0	2.0×10^{-4}	1.6×10^{-3}	6.7×10^{-3}
Euphorbia tirucalli	3.0×10^{-2}	1.9×10^{-1}	2.5×10^{-2}	7.1×10^{-2}	5.7×10^{-3}	0.0	0.0	2.0×10^{-4}	2.2×10^{-3}
Blepharis linariifolia	3.8×10^{-2}	1.3×10^{-1}	2.3×10^{-2}	9.2×10^{-3}	4.4×10^{-3}	0.0	2.0×10^{-4}	3.0×10^{-4}	3.2×10^{-2}
Indigofera spinosa	3.3×10^{-2}	2.3×10^{-1}	3.5×10^{-2}	1.3×10^{-2}	7.2×10^{-3}	0.0	2.0×10^{-4}	5.0×10^{-4}	5.3×10^{-3}
Dobera glabra	3.3×10^{-2}	1.7×10^{-1}	2.4×10^{-2}	3.4×10^{-2}	7.7×10^{-3}	3.0×10^{-4}	2.0×10^{-4}	1.0×10^{-4}	1.1×10^{-3}
Barleria proxima	3.9×10^{-2}	3.1×10^{-1}	2.7×10^{-2}	6.0×10^{-2}	5.0×10^{-3}	0.0	2.0×10^{-4}	3.0×10^{-4}	2.2×10^{-2}
Indigofera cliffordiana	3.9×10^{-2}	2.1×10^{-1}	2.6×10^{-2}	2.4×10^{-2}	5.0×10^{-3}	8.0×10^{-4}	0.0	3.0×10^{-4}	6.5×10^{-3}
Lorianthus spp.	4.6×10^{-2}	0.0	4.0×10^{-2}	1.6×10^{-2}	5.5×10^{-3}	0.0	2.0×10^{-4}	1.0×10^{-4}	1.6×10^{-3}
[a]Recommended requirements in diets	3	1-3	2	6-8	6.0×10^{-1}	3.0×10^{-5}	1.0×10^{-4}	1.0×10^{-2}	30

[a]Source: Kuria et al., 2004 (Quoting from McDowell, 1985 and NRC, 1989) reporting on recommended requirements in diets while the figures reported here are for individual plants. The units used were gm/kg DM.

5.4 Discussion

The results show the forage species commonly browsed by camels in Isiolo County of northern Kenya mainly comprise of trees, shrubs, dwarf shrubs and herbs (Tables 5.2a and 5.2b) consistent with previous observations (Wangoi, 1984; Rutagwenda et al. 1990; Field, 1995; Kuria et al. 2004 & 2005). Similar findings were reported by Coppock et al. (1986a) stating that the dromedary camel has preference for browse trees and shrubs while Schwartz (1992b) also stated camels prefer bushes and trees to grasses. Several authors (Field, 1979; Wangoi, 1984; Kuria et al. 2004 & 2005) reported camels' special preference for dwarf shrubs, particularly *Indigofera spinosa* and *Duosperma eremophilum*. Consequently, these results corroborate the findings of the present study.

The results of this study provide evidence that seasonal fluctuation in nutritive value was marked in CP, CF and NDF, being superior in wet seasons compared to dry seasons. Crude protein and NDF contents are important determinants of nutritional quality of livestock forages. The CP range in the present study (Tables 5.2a, and 5.2b) were similar to the findings of Kuria et al. (2005) while the seasonal fluctuation manifested through a decrease in CP from wet to dry season was in agreement with Kayongo (1986), Elmi (1991), Field (1995) and Kuria et al. (2005). The dry season mean CP value (9.86%) was lower than the observation by Wilson (1998) that Kenyan camels were able to maintain a diet with a minimum CP content of 14% during dry season, implying worsening forage quality which may be attributed to effects of ongoing climate change phenomenon. In addition, the CP mean values for this study were lower than what had been reported by Elmi (1991) for both wet and dry seasons of 24.1% and 16.3% respectively. The increase in fibre (NDF) content of forages from wet to dry season (Tables 5.2a, and 5.2b) were consistent with earlier reports by Van Soest (1982), Wilson (1982), Rutagwenda et al. (1990), Field (1995), Kassilly (2002), and Kuria et al. (2005) who noted increased fibre content and decreased protein content as plants reach maturity.

Changes in forage quality could be linked to seasonal progression in plant phenology as previously reported by Coppock et al. (1986a) and Rutagwenda et al. (1990). This usually depends on rainfall pattern. In agreement with previous works (Coppock et al. 1986a; Rutagwenda et al. 1990; Kassilly, 2002; Kuria et al. 2005), during and immediately after wet (rainy) season, high quality forage characterized by young fresh leaves and shoots with high CP contents are available while those in dry season had mature shoots with lower CP and increased fibre content. Fluctuations in forage quality reported in the present study also agrees with the findings by Kassilly (2002) that camels in arid and semi-arid zones of northern Kenya live in a seasonal environment where changes in weather regimes influence the quality of their diets. Thus, as previously reported by Kuria et al. (2005), changes in diet quality, which deteriorates during dry season, directly affects camel performance (e.g. reduced milk production) and the subsequent well being of camel keepers. There is need therefore, for mitigation strategies in response to depressed nutritive value of browse forages in order to support dry season milk production.

In vitro dry matter digestibility (IVDMD) results (Table 5.3) show no apparent seasonal fluctuations. IVDMD values ranged from 0.50 to 0.83 and from 0.42 to 0.82 in wet and dry season, respectively. These values are higher than those reported by Coppock et al (1986b), Elmi (1989) and Dereje and Uden (2005b) of 0.25–0.48, 0.32–0.41 and 0.51, respectively. A number of factors, including type of plant species, their chemical composition and parts of plants analyzed may contribute to differences observed. It is possible that the numbers and diversity of bacteria (obtained from the two camel steers) may have been higher (Jones and Barnes, 1996), thus, better digestibility observed. Jones and Barnes (1996) also reported wide variation in the range of *in vitro* digestibility of shrubs (0.22–0.80). Similarly, Dereje and Uden (2005b) summarized documented *in vitro* dry matter digestibility of some camel browse plants showing a wide range of 0.23–0.70. However, the results of the present study agrees with the observation by Wilson (1998) that, given a choice, camels select best quality plant material both during wet and dry seasons.

The results of mineral concentration (Tables 5.5a and 5.5b) of the top ten forages commonly browsed by camels in Isiolo County of northern Kenya show clear interspecies differences both within and between seasons. The ranges of the different mineral concentration of the forages show wide variations. This is in agreement with Onjoro (2004) and Kuria et al. (2004) who reported such variations. These wide variations in mineral concentration in forages may be attributed to season, the different maturity stages of the forage materials and micro-variations in soil type and fertility. Mature plants are usually low in minerals due to translocation of nutrients to the root system (Kuria et al. 2004). According to a study conducted in the neighbouring Marsabit County, Kuria et al. (2004) reported that between 80 and 100% of forage species preferred by camels and those perceived as important camel forages by herders were adequate in terms of calcium, phosphorus, magnesium, potassium, sodium, iron and cobalt concentrations during both dry and wet seasons. However, the authors reported insufficient concentrations in zinc and copper levels. In the present study, based on the results of the three forage species (*Salvadora persica*, *Blepharis linariifolia* and *Maerua angolensis*) browsed in both wet and dry seasons, there was no clear trend in specific mineral element concentration in forages between seasons. Several authors (Kuria et al. 2004; Onjoro, 2004; Onjoro et al. 2006) have reported that mineral requirements of camels have not been scientifically established, and needs to be studied. Consequently, the mineral contents of the forages could have provided indications of normal, deficiency or excess levels if there was data for use in comparison. In addition, the current levels would have provided more information had the camel's requirements for individual minerals been determined. At the moment, only minimal data is available for comparison. For example, phosphorus content during both seasons is very close to the data of Elmi (1991), while data for calcium, potassium and sodium are much higher than those reported by Elmi (1991) (Table 2.7). The recommended requirements for several mineral elements in camel diets reported by Kuria et al. (2004) are given at the bottom of Tables 5.5a and 5.5b.

5.5 Conclusion

Results indicate the diverse nature of camel's diet, mainly comprising of trees, shrubs and dwarf shrubs. However, seasonal variations in nutritive values were marked, being superior during wet season and poorer during dry season and directly impacting on camel performance as well as livelihoods of the poor camel keepers. Thus, there is need for feeding intervention so as to sustain milk production.

CHAPTER SIX

EFFECTS OF FEED SUPPLEMENTATION ON PERFORMANCE OF LACTATING CAMELS ON BROWSE FORAGES IN A PERI-URBAN SYSTEM IN ISIOLO COUNTY, KENYA

6.1 Introduction

Analysis of nutritive values of camel browse forages in a peri-urban system practising restricted foraging within the urban market vicinity allows camels' access to only a limited variety of species of browse forages (Dereje and Uden, 2005a). The practice exerts pressure on available feed resource base, which gets severe during dry and drought periods, consequently depressing milk offtakes and diminishing livelihood benefits to pastoral poor households (chapter 3, 4 and 5). Faced with pressure on feed resource base, camel producers resort to feeding their camels on a non-conventional forage, *Euphorbia tirucalli* (Guliye et al., 2007; Field, 1995), instead of feeding on supplementary feeds capable of supporting sustained milk offtake, a situation also observed in Ethiopia (Baars, 2000).

Sustaining milk offtake under pressure on natural browse forage will require supplementary feeding to boost nutrient supply needed for maintenance and for milk synthesis. This study was therefore designed to answer the research question: can supplementary feeding improve or sustain milk yield, influence milk composition and body weight of lactating camels during dry season? Empirical evidence generated from a supplementary feeding trial can objectively inform on intervention to out scale for people investing in peri-urban camel production in arid conditions.

6.2 Materials and Methods

6.2.1 Experimental animals

Feed supplementation was restricted to dry/drought periods when feed supply declines in order to sustain milk yield from camels reared in peri-urban areas. The study was started in the middle of a dry season. The underlying assumption was that during the wet (rainy) season, there is an abundance of forages to meet the camel's nutrient requirements for maintenance and production. Lactating dromedary females were selected from the same herd beginning with visual assessment for abnormalities. For the selected females, the herd owner provided information on their stages of lactation, parity and the status of their calves. Only those females whose calves were alive and were of similar lactation period joined the experiment.

At the beginning of the experiment, all camels were de-wormed against endoparasites and sprayed once a week against ecto-parasites. Control of Trypanosomosis was achieved through use of Triquin (Quinapyramine sulphate and Quinapyramine chloride) as prophylactic measure.

Regular observation and rectal temperatures taken to detect any sub-clinical symptoms of disease did not reveal any adverse health problem on any experimental animal.

6.2.2 Dietary treatments and experimental design

Using a completely randomized design, eighteen (18) lactating Somali camels with parities between 2 to 4, and at mid-lactation (6 months), were randomly allocated, in equal number (n=6), to 3 treatments. Treatment one (T1) was control (range browsing only); Treatment two (T2) was range browsing plus Supplement 1 (S1) composed of barley straw (65%), Acacia pods (20%), molasses (10%), urea (3%) and dairy mineral lick (2%) (Plate 3); and Treatment three (T3) was range browsing plus Supplement 1, but with maize germ substituting Acacia pods in equal amounts to form Supplement 2 (S2).

All camels browsed in the range during the day for about 10 hrs and kept in a corral made up of thorny woody branches at night. At 5.00 pm, each camel in the supplemented group is enclosed in an individual corral pen and given 4 Kg/d of the feed supplements (S1 or S2) (Plate 4). For ease of identification and separation into the individual pens, each had identification number. The camels were watered once every day. Calves were allowed to run with their mothers during the day but corralled separately at night, to enable morning milking, after allowing the calf to suckle for few seconds to stimulate milk letdown.

Milking was done by the same herders (Plate 5) and milk yield measured in litres (Plate 6). Daily milk yield was estimated by doubling the amount obtained from complete milking (extraction) of all teats in the morning, to reflect the usual two times (morning and evening) milking frequency adopted by most camel pastoralists in northern Kenya (Simpkin, 1995; Farah et al., 2004a). No attempt was made to estimate the amount of milk consumed by calves, as there is no accurate estimation technique so far (Bekele et al., 2002).

Milk samples were collected once a week for seven weeks. During milk sample collection, equal proportions of milk were obtained from each camel in the same treatment and then pooled for each treatment, which is then sub-sampled and the milk frozen until analysis. Milk composition analysis to determine percent fat, protein, solids-not-fat (SNF), and density was done using infrared spectroscopy based machine, EKOMILK milk analyzer (BULTEH 2000, EON TRADING, Bulgaria). To monitor body weight changes, camels' weight was estimated once every week. The body weight of the camels was estimated as (kg) = shoulder height (cm) x thoracic girth (cm) x hump girth (cm) x 50, according to Wilson (1998). The estimated body weight of the experimental camels ranged from 526 kg to 541 kg. The trial lasted for 56 days – 14 days of adaptation period and 42 days of measurement period.

Plate 3: The researcher preparing the supplementary feeds

Plate 4: A camel feeding on supplementary feeds in a make-shift pen

Plate 5: One of the experimental camels being milked by herdsmen at the experimental site in Ngaremara area near Isiolo town, Kenya

Plate 6: The researcher (in cap) measuring milk yield using graduated glass flasks

6.2.3 Chemical analysis

The individual ingredients used to compound the supplementary diets and the mixed supplementary diets (Supplement 1 and Supplement 2) were subjected to proximate analysis (DM, CP, CF, Ash) according to AOAC (1995); and fibre component (NDF and ADF) according to the procedure of Van Soest et al. (1991). Mineral analysis was achieved by atomic absorption spectrophotometer (AAS) (Model S-11, manufactured by Thermo Jarrel Ash Corporation, USA). In addition, the energy content (MJ/Kg DM) was determined for individual ingredients used to compound the supplementary diets, the compounded supplementary diets and the plants eaten by control camels using bomb calorimeter, e2k model (www.cal2k.com). A different sample was collected to provide data on the composition and nutritive value of the diet consumed by the control group (i.e. natural browsing) following the procedure described by Sawe et al (1998). To achieve this, camels were followed (for 30 minutes in the morning and 30 minutes in the evening, twice per week for 3 weeks) and observed while browsing in the field and samples of the plants eaten by camels were collected and mixed in equal quantities, dried and analyzed.

6.2.4 Statistical analysis

To determine the effects of supplementation on animal response, data was summarised into the effects of treatments on milk yield, milk composition and body weight. Milk composition data was analyzed using descriptive statistics while the milk yield and body weight data were subjected to Analysis of Variance (ANOVA). Significance between means was tested using the least significance difference (LSD). The analysis was facilitated by using the Statistical Analysis System (SAS) software version 9.1.3 (SAS, 2003).

6.3 Results

6.3.1 Effects of feed supplementation on milk yield

Analytical results of the main individual feed components used to make the supplementary diets and the control and supplementary diets are presented in Tables 6.1 and 6.2, respectively. From the outset, the results in Table 6.1 reveal that the two feed components differ in their major nutrient contributions. While Acacia pods are a protein source, the maize germ is an energy source. The chemical composition of the two dietary supplements presented in Table 6.2 does not reveal major differences.

Supplementation with maize germ-based diet (T3) significantly ($p<0.001$) improved milk yield by 26% and 50% over Acacia pods-based diet (T2) and the control (range browsing only) (T1), respectively (Table 6.4). Multiple mean comparisons (Table 6.3) for the three treatments showed the values 4.8, 3.8 and 3.3 litres/day for maize germ-based supplement (T3), Acacia pods-based supplement (T2) and control (T1), respectively, were significantly ($p<0.001$) different.

Table 6.1: Chemical analyses of acacia pods and maize germ used to compound the supplementary diets.

Diet component	Chemical composition				
	CP (%)	CF (%)	NDF (%)	ADF (%)	Energy content (MJ/kg DM)
Acacia pods	17.45	22.98	32.20	26.28	15.58
Maize germ	9.45	10.46	40.60	8.80	17.68

Table 6.2: Chemical analyses of the control and supplementary diets

Dietary treatment	Chemical composition				
	CP (%)	CF (%)	NDF (%)	ADF (%)	Energy content (MJ/kg DM)
Range browsing (T1)*	7.71	53.06	55.35	42.38	15.84
Acacia pods-based supplement (T2)	13.72	53.08	59.08	42.38	14.90
Maize germ-based supplement (T3)	11.01	29.64	51.45	26.05	16.57

* The control diet was also eaten by camels on supplementary diets. Chemical composition of the control diet is included here to give a picture of the quality of camel diets, even under extremely difficult circumstances, based on their selective feeding habits. The T1 values are not intended for comparison with those of the two supplements.

Table 6.3: Least significance difference (LSD) for milk yields multiple mean comparisons.

Treatment	Samples (n)	Mean	S.E.
Range browsing (T1)	42	3.26^a	0.14668
Acacia pods-based supplement (T2)	42	3.82^b	0.07974
Maize germ-based supplement (T3)	42	4.82^c	0.04296

Means with different letters (a, b, c) are significantly ($p<0.001$) different.

Table 6.4: Effects of supplementing acacia pods or maize germ based diets to lactating Somali camels browsing during the day on milk yield, composition and body weight.

Response parameters	Range browsing (T1)	Acacia pods-based supplement (T2)	Maize germ-based supplement (T3)
Milk yield (litres/day)	3.26 ± 0.95[a]	3.82 ± 0.52[b]	4.82 ± 0.29[c]
Milk composition			
Fat (%)	1.92 ± 0.236	2.32 ± 0.283	1.99 ± 0.258
Protein (%)	3.07 ± 0.081	3.47 ± 0.094	3.46 ± 0.141
SNF (%)	8.00 ± 0.101	8.47 ± 0.114	8.47 ± 0.167
Density (%)	25.71 ± 0.510	27.30 ± 0.534	27.54 ± 0.530
Body weight changes			
ADG/loss (g/day)	-178.6	-95.3	-74.1

Means with different superscript letters in a row differ significantly ($p<0.05$).
Legend: CP=Crude Protein, SNF=Solids-Not-Fat, ADG=Average Daily Gain.

6.3.2 Effects of feed supplementation on milk composition

Table 6.4 also presents the gross composition (%) of the major camel milk constituents obtained from the different treatments. No major differences were observed in the quality of milk between the dietary treatments.

6.3.3 Effects of feed supplementation on body weight

Body weight changes of experimental camels are reported as average daily gain/loss (g/day) and the results are highlighted in Table 6.4. Supplementation did not result in weight gain. Rather, drop in body weight was observed across all treatments. However, the severity in the drop were T3 < T2 < T1, being -74.1, -95.3 and -178.6 for maize germ-based, Acacia pods-based and control, respectively. Significant ($p<0.0260$) dietary differences were detected with supplementary feeding with maize germ-based diet (T3) resulting in the highest means followed with Acacia pods-based diet (T2) and the control (T1) group, respectively. Multiple mean comparisons (Table 6.5) using the least significant difference (LSD) method revealed the following treatment pairs have significant differences in their means: T3 and T2, and T3 and T1. However, the means for T1 and T2 were not significantly different.

Table 6.5: Least significance difference (LSD) for body weights multiple mean comparisons.

Treatment	Samples (n)	Mean	S.E.
Range browsing (T1)	42	506.44[a]	3.6929
Acacia pods-based supplement (T2)	42	507.06[a]	7.1651
Maize germ-based supplement (T3)	42	524.78[b]	5.4444

Means with the same letter are not significantly different.

6.4 Discussion

The evidence obtained in this study indicates that dry season feed supplementation results in positive response in milk yield of lactating camels. Lactating camels showed the best response to supplementation with maize germ-based supplement (T3) compared to Acacia pods-based supplement (T2) and control group (T1) (Table 6.4). This finding is in agreement with Dereje and Uden (2005a) who found that lactating camels feeding on the range show a good response in milk yield when supplemented with protein or energy feeds. Both energy and protein are critical nutrients for milk production in livestock. A higher response observed with maize germ supplementation may not be explained by the slightly higher energy content of maize germ (Tables 6.1 and 6.2), but possible nutrient availability to animals, which is likely to be better in maize germ. Maize germ-based supplement has much lower CF, NDF and ADF values. The lower these values, the more the feed is digestible, thus, more nutrients available to animals. In feeding animals, feeds with low neutral detergent and acid detergent fibre values are desired. The mean milk yield levels for all the treatments were reasonably close to the result of Bekele et al (2002) for Eastern Ethiopian camels (4.14 kg/day), Simpkin (1993) for Kenyan camels (2.4 – 4 kg/day) and Baars (2000) for Eastern Ethiopian camels (3.6 – 6.5 kg/day). However, the mean levels obtained in the present study for supplemented groups (T2 and T3) were relatively low compared to the findings of Dereje and Uden (2005a), which were 12.2, 8.6 and 6.9 kg/day, resulting from twice milking, during dry season for browsing Ethiopian camels supplemented with protein and energy supplements, and the control, respectively. The most likely reasons for the large differences in the yields relate to the fact that the experimental camels in the two experiments were at different stages of lactation and also the proportions of protein and energy components in the treatment diets were different (theirs being higher). Bekele et al (2002) observed that the discrepancy in milk yield figures may emanate from the fact that previous findings reported not actual measured milk offtake but estimated total milk yield by considering 50% allowance for the suckling calf. Bekele et al (2002) also observed that dry months may have a negative effect on milk producing ability of camels. This may be attributed to severity of feed shortage coupled with the discomfort to the camels associated with high ambient temperatures and direct solar radiation.

Previous studies (Zimmermann, 1982; Salih, 1985; Hashi, 1988; Little, 1989) have demonstrated that a commonly-used strategy is to purchase supplementary fodder for the animals to compensate for the shortfall resulting from the inadequate natural browsing. In the present study area, it is unfortunate that availability of alternative supplementary fodder is a major challenge. Feeding camels therefore becomes a difficult experience in the dry season. Herd owners, however, have no choice but to devise new strategies to feed their camels in order to sustain and/or maximize milk output for family consumption and for sale. Consequently, camel owners in the study area have resorted to feeding their camels on the hedges of *Euphorbia tirucalli*, a non-conventional camel forage, at a fee, to overcome feed constraints. In a recent study, Mahmoud (2010) revealed that camel keepers in Moyale region have developed exceptional ways to feed their camels. They fed camels on a "soup" made from boiling the meat of sheep and goats, oil and sugar; and the chaff of wheat boiled with sugar. However, whether their action makes economic sense is unclear.

The evidence obtained in this study indicates that feed supplementation has not resulted in marked difference in quality of milk (Table 6.4). The range of mean levels for all the treatments were within the ranges reported in previous studies (Yagil, 1982; Mal, 2000; Farah, 2004b; Mal and Sena, 2007). A number of factors contribute to differences in milk composition parameters. Previous studies (Simpkin, 1993; Mal, 2000; Mal and Sena, 2007) have demonstrated that the composition of camel milk varies with availability of drinking water, breeds, stage of lactation and milk production potential. For example, Mal and Sena (2007) found that protein content was highest while fat content was lowest in breeds with better milk production potential.

The effect of feed supplementation on body weight was assessed using both average daily gain/loss (g/day) and changes in absolute body weight (kg). Both procedures revealed a drop in body weight of experimental animals across all treatments. However, the severity in the drop, calculated as ADG/loss (g/day), were T3 < T2 < T1, being -74.1, -95.3 and -178.6 for maize germ-based, Acacia pods-based and control, respectively (Table 6.4). Similarly, the results showed a significant ($p<0.0260$) difference in the weekly weights (absolute) of the camels, with the highest means being observed in camels supplemented with maize germ-based supplements. The observed drop was hardly surprising since the study was conducted during dry season. It is worth noting that the amount of supplementation diets (T2 & T3) were maintained constant throughout the experiment while the basal diet (range browsing) was constantly going down as the severity of feed shortage worsens. Although the critical minimum levels of the different nutrients for maintenance of camels have not been established, it is reasonable to conclude that the weight loss observed is an indication that the animals were not getting enough during browsing and the level of supplementation may have been inadequate to offset the demand deficit. Consequently, future experiments may have to try higher levels.

6.5 Conclusion

Supplementary feeding shows positive effect capable of mitigating dry season feed shortage. Based on the findings of this study, camel keepers can improve their dry season camel milk yield and minimize loss in body weight by supplementing with maize germ-based supplements.

CHAPTER SEVEN

GENERAL DISCUSSION

7.1 Rationale of the study

The observed changing camel management strategies in arid northern Kenya motivated the objectives of the study. Several camel studies (Wilson, 1998; Farah et al., 2004a; Guliye et al., 2007; Mehari et al., 2007a and 2007b; Mahmoud, 2010) report changes in camel management strategies from free herd mobility that enables pastoralists utilize extensive communal rangeland resources more efficiently to restricted grazing within the vicinity of urban milk market outlets. Restricted camel grazing within the vicinity of urban milk market outlets accumulates pressure on forage feed resources while market-oriented production pressurizes pastoralists to adjust their herd management practices to market responsiveness. Continued pressure on feed resource base and herd management practice irresponsive to market requirements can impede development of the emerging peri-urban camel production system and diminish its livelihood benefits to pastoral households. Therefore, this study was designed to contribute to sustainable growth of peri-urban camel production system through improved feeding and marketing of camel products and surplus stock. To achieve this objective, four research questions were formulated:

(i) What are the distinctive characteristics of the emerging PUCPS?

(ii) What are the drivers for its development?

(iii) What are the challenges to its sustainable development?

(iv) Which intervention options would support its sustained development?

7.2 Study methodology and challenges encountered

Data was obtained through a mix of methodologies relevant for answering the research questions. Cross sectional surveys were conducted of peri-urban and pastoral systems of camel production to gain better understanding of the characteristics of the emerging peri-urban camel production system in reference to the pastoral subsistence system (chapter three). In addition, a focus group discussion with camel stakeholders including producers, milk and stock traders, development agencies and regulatory authorities was organized to complement information from the surveys. The survey data enabled for assessment of the extent of market responsiveness of herd management practices (chapter four). Laboratory analyses of common forage plants browsed by camels was conducted to understand the seasonal fluctuation in quality (chapter five). Feeding trials with lactating camels (chapter six) was designed to determine the effects of supplementary feeding on milk yield, milk composition and body weight responses.

These approaches adopted had some challenges. Data collection from a migratory population and without herd record keeping practice in cross sectional surveys presented difficulties in ensuring random sample population of respondents and reliable data on animal performance. Therefore, a focus group discussion with camel stakeholders was organised to complement information from the surveys and to improve reliability of the information. Laboratory analyses of nutritive values of common camel forages (chapter five) enabled objective corroboration of subjective data from cross sectional surveys and focus group discussions. In the feeding trials, the adaptation period had to be prolonged to enable camels adapt to confined feeding conditions because the animal could feed on one day and refuse to feed the next day, or reject to feed in trough and sometimes break fence to feed from another trough. There were challenges in accurate measurements of milk yields because calves could suckle in more than one cycle of milk letdown. Formulation of the supplementary feed could not be possible to the requirements of the camel because the specific nutritional requirements of camels have not evolved as in other domestic milking animals. The results of this study have been shared with stakeholders in a feedback workshop and in seminars and conferences.

7.3 Research findings

7.3.1 Distinctive characteristics of the emerging PUCPS

Livelihood roles

This study provides evidence that camels are primary source of livelihoods for pastoral communities even as they transition to semi-sedentary urban lifestyle and milk is the key product. This finding is in agreement with results of several previous camel studies (Wilson, 1998; Farah et al., 2004a; Guliye et al., 2007; Mehari et al., 2007a and 2007b; Mahmoud, 2010). With increasing sedentarization, camel milk is increasingly commercialized and consumed in urban areas. In northern Kenya, the emergence of peri-urban camel milk systems are encouraged by increased commercialization of camel milk resulting from increased demands by urban populations, particularly members of pastoral communities who have migrated to urban centres in search of business and employment opportunities (Simpkin et al., 1996).

Camel milk is increasingly attracting interest due to its perceived medicinal properties by pastoral communities. In this regard, Wernery and Wernery (2010) state that, camel milk, which has been consumed for centuries by nomadic people for its nutritional values and medicinal properties, is now experiencing greater awareness in the western world. Furthermore, while the Food and Drug Administration has recently agreed to add camel's milk to the list of saleable products in the United States (Cromvoirt Journal, 2009), Faye (2007) notes that the health-promoting properties of camel milk are strong boost for sales and, in certain regions such as the

Middle East, they are the drivers for intensification of camel dairying. Despite these attributes, Wilson (1998) states that peri-urban camel systems are transitional and predicts it will not be sustainable in the long term as urban populations increase and environmental concerns become more important. However, the same author believes forage production and the use of new technologies are among opportunities that may improve both profitability and sustainability of peri-urban camel systems. In agreement with the foregoing, the present author believes adoption of new technologies such as dry season feed supplementation, maintenance of high level herd hygiene and disease control practices responsive to market demands, will contribute to sustainable growth of PUCPS.

Feeding characteristics

The camel is, by preference, a browser of a broad spectrum of forage plants, including trees and shrubs (Coppock et al., 1986a; Wilson, 1989; Field, 1995). The present finding where browse forages are found to be important camel feed resource in both peri-urban and pastoral camel production systems of Isiolo County (Figure 3.8) is in line with previous observations (Rutagwenda et al., 1989; Field, 1995). An important feature of camels' browsing habits is that they are not in direct competition with other domestic animals either in terms of the type of feed eaten or in the height at which they eat above the ground (Wilson, 1989). Comparative studies by Rutagwenda et al. (1989) on the dietary preferences of indigenous camels, cattle, sheep and goats in a semi-arid thorn-bush savannah in northern Kenya established that cattle and sheep preferred vegetation at ground level, mostly consisting of grasses, herbs and small shrubs. On the other hand, goats browsed up to 2 metres above the ground (mainly on herbs and small shrubs), whereas camels were capable of reaching plants up to a height of 3 metres, mostly comprising of deep rooted large bushes and trees. Thus, during the dry season when leaves of large perennial trees may be the only green vegetation available, camels and to some extent goats benefit greatly compared to cattle and sheep. However, camels are quite capable of feeding on grasses at ground level, as shown by the findings of the present study (Figure 3.8), possibly as an adaptation to feed shortages. The importance of grasses as feed resources for camels in the peri-urban production system compared to the pastoral system, may be attributed to the high concentration of camels in the peri-urban system, leading to over-exploitation of available browse forages thus making camels to rely on grasses.

Marketing characteristics

This study provides evidence of market integration of live camels and camel milk in Isiolo and Nairobi urban markets. Compared to pastoral system, peri-urban camel system exhibits greater market oriented production in disposing surplus stock (Table 4.1), purchasing breeding stock and selling more milk to market (Figure 3.3). In agreement with the present findings, a recent study (Mahmoud, 2010) reported the existence of a vibrant and lucrative live camel market in the northern Kenya border town of Moyale where several market actors (herders, traders, brokers) were making good gains. Similarly, Farah et al. (2004a) observed that highly attractive prices and other strong incentives were attracting more and more pastoralists into the market economy. Other studies (Simpkin, 1993; Heath, 1997; Farah, 2004a; Farah et al., 2004a) also reported existence of trade in live camels and camel products (milk and meat).

The increased commercialization of camel milk in urban niche markets observed in Kenya in the present study, is similar to trends reported in neighbouring countries like Somalia (Herren, 1990; Farah et al., 2007) and Ethiopia (Seifu, 2007; Mahmoud, 2010), as well as in other African countries such as Djibouti, Mauritania, Morocco and Sudan (Wilson, 1998). In the peri-urban system, the sale of camel milk is an important economic activity, attributable to the prospect of better returns arising from the increasing demand for camel milk in urban markets like Nairobi. With milk for sale being the most important production function, the results of this study demonstrate a peri-urban camel system, as a market oriented production system, reflects the changing roles of camels with progressive market integration. In contrast, in the pastoral system, camels are mainly kept for subsistence purposes and there is less emphasis on milk marketing. However, poor milk hygiene (Table 3.2), subjective milk quality testing (Figure 4.2) and vulnerability to disease incidences could be barriers to accessing expanded niche urban markets.

7.3.2 The drivers for development of PUCPS

The emergence of Isiolo peri-urban camel production may have begun in the early 1990s (Figure 3.4), in response to market demands for camel milk and has rapidly increased since then. Three factors may have contributed to the emergence of market-oriented peri-urban camel milk production around Isiolo. Firstly, there may have been progressive sedentarization of pastoral communities with a camel keeping background in and around Isiolo town since 1972. Secondly, the emergence of a niche market for camel milk in Nairobi's Eastleigh area following the influx of Somali refugees, with strong traditions of camel milk consumption, following the collapse of the neighbouring Somali government in 1991 and the subsequent instability that followed.

Thirdly, the presence of a reliable (tarmac) road and daily means of public transport (i.e. buses) for transporting milk from Isiolo town to the main camel milk market in Nairobi.

The settling by formerly mobile pastoral populations near urban towns has been reported to be occurring rapidly throughout East Africa, in response to drought-induced livestock losses, increased involvement in market economies and violence of livestock raiding and ethnic conflicts (Fratkin, 2001; McCabe, 2004). Consequently, in agreement with the foregoing, the sedentarization process observed in the present study contributes to growth of peri-urban system through provision of ready market, particularly those with strong tradition for consumption of camel milk and medicinal use, get access to the commodity. The niche market in Nairobi contributes to the growth of peri-urban camel milk production system by linking producers to urban consumers of camel products (milk and meat). The presence of a reliable (tarmac) road and daily means of public transport (i.e. buses) for transporting milk from Isiolo town to the main camel milk market in Nairobi contributes to the growth of camel milk market by providing communication between production area and urban markets. Isiolo peri-urban camel producers strategically locate their herds near roads leading to Isiolo town for ease of milk marketing. Good road network enhances access to the market since milk is a highly perishable commodity that deteriorates quickly under ambient temperature.

7.3.3 Challenges to sustainable development of PUCPS

Feeding challenges

The evidence obtained in this study indicates that although camel keepers in both peri-urban and pastoral systems of Isiolo County face feed shortages during the dry and drought periods of the year (Table 3.2; and Figure 3.7), the severity in the dry season is significantly higher ($p<0.001$) in the peri-urban system. This may be due to the higher concentration of camels within Isiolo peri-urban area, exerting enormous pressure on feed resources. In addition, the effects of recurrent droughts that reduce both quantity and quality of feed resources and seasonality of camel forage availability pose major challenges to the development of Isiolo PUCPS.

In agreement with observations of previous studies (Field, 1995; Maundu and Tengnas, 2005; Guliye er al., 2007), the results reveal that the feed shortage experienced during the dry and drought periods compel many camel owners to move their herds to Isiolo town so that their animals can browse on a non-conventional camel forage, *Euphorbia tirucalli,* instead of feeding on supplementary feeds capable of supporting sustained milk offtake. Consequently, the plant has become an important feed resource in Isiolo peri-urban camel production (Figure 3.8), such that camel owners pay the Euphorbia owners so that their camels can browse, especially during dry and drought periods when feed shortages are severe. Although it is used as an alternative feed resource, its nutritive value and possible effects on camel products (such as milk and meat) are unknown. In contrast, camel keepers in the pastoral system, where milk marketing is not a priority production objective, exploit distant forages through seasonal mobility within the rangelands and probably suffer less from the effects of droughts that cause forage shortages. However, such flexibility is not available in the peri-urban system as camel herds have to stay in close proximity to the milk market in Isiolo town. In addition, the use of cultivated forages, crop residues and supplementation with commercial feeds is not practiced in camel production systems of Isiolo County, similar to previous observations reported from neighbouring Ethiopia (Baars, 2000).

Marketing challenges

The findings of the present study indicating diseases as important constraints to camel production in Isiolo County (Table 3.2) is in agreement with observations reported in other parts of northern Kenya (Rutagwenda, 1983; Dioli and Stimmelmayr, 1992; Noor, 1999; Ngaira et al., 2003) and in Ethiopia (Baars, 2000). The disease problem in camels is compounded by severe shortage of qualified animal health workers (especially veterinarians) and the inability of most available workers to provide reliable treatment and disease control services because of their limited exposure to, and understanding of camel diseases.

The problem of milk spoilage (Table 3.2) is of great concern to camel producers in the peri-urban production system of Isiolo, as it causes direct economic loss to both producers and camel milk traders. In agreement with present results, Farah et al., (2004b) identified the main constraints of the emerging camel milk market as: (i) poor hygienic quality of the commercialized milk, and (ii) lack of milk processing technologies to improve shelf life and expand production and sales. In addition, trading in camel milk presents a peculiar challenge relating to consumer preference. The observations by Farah et al. (2007) and Seifu (2007), that most camel milk traders buy only fresh milk from producers, since most camel milk consumers prefer fresh milk (i.e. not fermented) was also revealed in this study. However, there is health risks associated with the consumption of raw milk (Farah et al., 2004b; Matofari et al., 2007; Akweya et al., 2010b; Meile, 2010; Wanjohi et al., 2010; Matofari et al., 2013), which could limit wider marketing opportunities amongst non-camel keeping communities. The problem of frequent milk spoilage observed in the present study may be due to inadequate clean water in areas where camels are reared, use of inappropriate containers (such as plastic jericans) for milk storage and transportation (Farah et al., 2007), and lack of adequate understanding of the principles of clean milk production by camel keepers.

Sensitivity to disruption of peace and stability

The findings of the present study indicating decline in the number of camel milk traders in Isiolo County between 1999 and 2001 (Figure 3.5), probably due to violence of livestock rustling, ethnic conflicts and general insecurity is in agreement with observations reported in other parts of East Africa by Fratkin (2001) and McCabe (2004). In the present study area ethnic conflicts led to many camel producers moving away from the peri-urban area. However, as soon as relative peace returned, there was renewed growth in the number of camel milk traders. Peaceful coexistence amongst communities in Isiolo is not only a great incentive for the growth of the peri-urban camel production but also for the overall camel milk business.

7.3.4 Suggested interventions to support development of PUCPS

Feed supplementation

The findings of the present study indicating dry season feed supplementation results in positive response in milk yield of lactating camels (Table 6.4) is in line with previous observations (Dereje and Uden, 2005a). Thus, availing appropriate and affordable camel feeding interventions to mitigate feed shortage during dry and drought periods would help support milk output and household incomes. However, formulation of appropriate feed supplementation protocol still remains a challenge (Farid, 1995; Wilson, 1998) since specific nutritional requirements of camels have not evolved as in other domestic milking animals. Supplementary feeding is a well known and established concept. Its successful implementation entails establishing available 'best' feed materials, determining proportions for inclusions in diets, and their cost implications. In this regard, Simpkin (1995) noted that supplementary feeding or zero grazing of camels in arid areas would only be worth implementing in locations where supplementary fodder is locally available, and where there is a local market for camel milk. The existence of the latter has been confirmed in the present study. Unfortunately, there aren't many alternative supplementary fodder available in the area. Forage production is also not a feasible alternative. Most of the supplementary inputs and supplies must, therefore, be purchased from outside the County of Isiolo.

To ease the unavailability of purchased feed resources to producers, there is need to organize them into farmer groups and cooperatives, to enable cost-effective purchase of required feed inputs and supplies to members. In this regard, the support of government and other development agencies will be imperative for initial take-off period. In addition, individual entrepreneurs willing to venture into stocking dry season supplementary feed resources for lactating camels reared near urban centres would be highly welcome. Energy and protein-based components and feed additives such as molasses, need to be stocked. Producers will then practice semi-zero grazing herd management system where the milking herd will go out to forage during the day but return to some form of feed supplementation in night corrals. With market orientation, milk price will be high and feed supply through market will be attractive.

Market linkage and access

The ability of camels to survive severe drought periods better (Table 3.6) than other livestock species is a unique attribute attracting development attention with a view to developing markets for live camels and camel products and also strengthening processes that add value to the products (LPP, LIFE Network, IUCN-WISP and FAO, 2010). In line with the observation of Noor (1999), interventions to overcome marketing challenges include public–private partnerships in improvement of infrastructure, general security, sound livestock marketing policies and initiation of market information flow to minimize exploitation of the producers by traders and middlemen. There is need for organized marketing channels that will not only enhance development of new markets for live camels within the country but also provide link to export markets.

Poor milk hygiene and subjective milk quality testing could be barriers to accessing expanded niche urban markets. To enhance marketing of camel milk, the quality and safety of the products for consumers needs to be seriously addressed through investment in milk processing plant at Isiolo to pasteurize and add value for the growing niche urban town markets in Kenya. In addition, there is need to develop and adopt scientific camel milk hygiene and quality testing methods which would be introduced through cooperatives and organized producer groups.

The emerging peri-urban camel milk production system of Isiolo is sensitive to disruption of peace and stability. This has negative implication for continued growth of the system. Therefore, there is need to maintain security, particularly in the production area, so as to sustain the ongoing development of market-oriented camel milk production system.

To address the challenge associated with camel diseases, the weak veterinary service delivery in ASALs calls for improved public and private efforts in terms of recruitment of qualified personnel and establishment of veterinary diagnostic facilities, strategically located within camel producing areas to facilitate rapid identification of diseases. In addition, a deliberate policy attention is needed to strengthen the use of CAHWs, in animal health service delivery and to appropriately integrate their activities into the formal animal health delivery system, subject to some training and regular supervision.

7.4 Conclusions

1. The camel is slowly but steadily gaining significance as a dairy animal for commercial milk production. In the last decade, there is an emergence of market-oriented peri-urban camel production around Isiolo town (northern Kenya), in response to increased demands for camel milk in Nairobi niche market.
2. The majority of camel keepers in Isiolo peri-urban production system built their herds through purchase of foundation stock, whereas camel herds in the pastoral system were mainly built through inheritance.
3. With regards to livelihood support, camels ranked as the most important in both production systems, whereas non-livestock livelihood sources (e.g. crop farming and formal employment) ranked lowest.
4. The major constraints facing camel producers in Isiolo County are camel diseases, inadequate feed resources and frequent cases of milk spoilage.
5. To overcome the disease problem, camel producers either engage the services of community-based animal health workers or use traditional treatment methods.
6. The most important mitigation strategy adopted by camel keepers to cope with the problem of inadequate feed resources, commonly experienced during dry seasons, is the use of *Euphorbia tirucalli* as forage for camels.
7. Seasonal fluctuations in forage nutritive values were marked, being superior during wet season than during dry season.
8. Appropriate and affordable camel supplementary feeding interventions, to mitigate feed shortage in dry and drought periods, would help support milk output and household incomes.
9. The problem of milk spoilage, which causes direct economic loss to both producer and camel milk traders, can be overcome, at least in part, by providing water sources within camel keeping areas, use of appropriate milk containers for storage and transportation of milk, and educating camel herders on clean milk production.
10. Poor milk hygiene, subjective milk quality testing and inefficient disease control practices could be barriers to accessing expanded niche urban markets.
11. Marketing of camel milk can be enhanced through investment in milk processing plant at Isiolo to pasteurize and add value for the growing niche urban town markets in Kenya.
12. Compared to pastoral system, peri-urban system exhibits greater market oriented production in disposing surplus stock, purchasing breeding stock and selling more milk to market.

7.5 Recommendations

1. Interventions needed to support the growth of Isiolo peri-urban camel production system are those that will improve animal productivity, processing of milk, organizing farmers and support for development of a value chain beneficial to all stakeholders.
2. Research is vital to effectively design these proposed interventions. Research has to be combined with training on improving productivity, hygiene milk production, handling, and processing to add value and enterprise development.
3. In order to enhance the development of the camel sector in northern Kenya, there is an urgent need to improve animal health services, through recruitment of qualified personnel and establishment of veterinary diagnostic facilities, strategically located within camel producing areas to facilitate rapid diagnosis and treatment of diseases. In addition, a deliberate policy attention is needed to strengthen the use of CAHWs, in animal health service delivery and to appropriately integrate their activities into the formal animal health delivery system, subject to some training and regular supervision.
4. To overcome inadequate feed resource challenge, there is need for sensitization of producers through training workshops on the practicality of feed supplementation to lactating camels, particularly during dry seasons.
5. To ease the unavailability of purchased feed resources to producers, there is need to organize them into farmer groups and cooperatives, to enable cost-effective purchase of required feed inputs and supplies to members.
6. Although the present study demonstrated improved milk yield as a result of dry season feed supplementation, there is need for further research to include cost–benefit analysis in order to determine economic viability of the supplementary feeding.
7. The problem of milk spoilage can be overcome through provision of water sources within camel producing areas, provision of appropriate milk containers, and educating camel herders on clean milk production. Such interventions will not only reduce post-production losses but also provide safe and quality camel milk to consumers.
8. The need for often stated long-term, on-station/controlled, camel feeding experiments aimed at generating data on their nutritional requirements which will assist in designing appropriate supplementation protocol remains urgent.

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APPENDICES

Appendix 1: Structured interview guide for peri-urban camel production around Isiolo town, northern Kenya

Questionnaire number ____

Enumerator's name ____

Date of interview DD _______ MM _______YEAR____ Location________________

A. Herd owner/respondent characteristics

Record personal details about herd owner or hired caretaker.

Particulars/characteristics	Herd owner details
1.1 Name	
1.2 Gender: 1 Male 2 Female	
1.3 Age (in years)	
1.4 Ethnic affiliation	
1.5 Educational level	
1.6 Major occupation	

Ethnic affiliation	Education level	Major occupation **0. None**
1. Boran	0. None	1. Livestock keeping
2. Somali	1. Primary	2. Business
3. Turkana	2. Secondary	3. Formal employment
4. Gabbra	3. Post secondary college	4. Others (specify)
5. Rendille	4. University	
6. Others (specify)		

B. Camel ownership and production objectives

1. Rank importance of camels compared to other sources of livelihoods to your household needs:

Camels	Cattle	Sheep &goats	Business	Formal employment	Crop farming	Remittances

3 = Highest importance; 2 =Average importance; 1 = Low importance; 0 = No importance

2. Was your first/foundation herd acquired through? [ ]

Inheritance from family

Purchase

Both inheritance and purchase

3. Rank the contribution of camels to your household needs:

	Rank
1. Milk for selling	
2. Progenies (offspring) sale	
3. Transportation means	
4. Socio-cultural needs (e.g. dowry)	
5. Cash from recreation (e.g. riding, racing)	
6. Form of wealth	

3 = Highest importance; 2 = Average importance; 1 = Low importance; 0 = No importance

4. Record the total number of camels in the herd:

	Camel number
Owned by the household	
Kept but not owned by the household	
Total number of camels in the herd	

5. How did the recent (2006) **drought** affect your livestock?

Species	Lost (Died)	Survived
1. Camels		
2. Cattle		
3. Sheep		
4. Goats		

C. Camel management systems

1. State the system of camel keeping you practice:

Presently	≤ 10 years ago	> 10 years ago

1 = Only pastoral system; 2 = Peri-urban/semi-sedentary system

2. Rank the reasons that necessitated you to adopting the present system of camel keeping

	Rank
1. System is traditional in this area	
2. Extension officers and other promoters influence	
3. Found the system more suiting to urban conditions	
4. Any other reasons (specify)	

3 = Highest importance; 2 = Average importance; 1 = Low importance; 0 = Not of any importance

3. Rank factors that encourage keeping of camel around Isiolo town.

Factors	Rank
1. Pastures and water available	
2. Easy access to urban market for camel milk, meat and live camels	
3. Easy access to better urban social amenities including schools, hospitals, roads, business opportunities	
4. Improved security	
5. Other reasons (specify)	

3 = Highest importance; 2 = Average importance; 1 = Low importance; 0 = Not of any importance.

4. Rank the importance of the following types of land ownership for the grazing of your camel herd:

Types of land ownership	Rank
1. Communally owned land	
2. Government owned land	
3. Self owned land	
4. Land leased from others	

3 = Highest importance; 2 = Average importance; 1 = Low importance; 0 = Not of any importance

D. Feed resources

1. Rank the importance of the following feeds for feeding your camel herd:

Types of feed resource	Rank
1. Native browses (Trees and shrubs)	
2. Native grasses	
3. Non-traditional feed resources e.g. Euphorbia	
4. Cultivated forages	
5. Crop residues	
6. Purchased commercial feeds	
7. Others (Specify)	

3 = Highest importance; 2 = Average importance; 1 = Low importance; 0 = Not of any importance

2. List the forages predominantly browsed by camels during wet, dry and drought periods in this area:

Wet season	Dry/drought season
1.	
2.	
3.	
4.	
5.	

NB: Can use local names, but will be translated

E. Feeding strategies

1. How far (in Km) do you go grazing your milking herd from Isiolo town during the different seasons?

Wet season	Dry/drought season

2. How severe is the feed shortage in your location during the different seasons?

Wet season	Dry season	Drought periods

3 = Shortage very severe; 2= Shortage moderately severe; 1 =Shortage low; 0 = No shortage

3. Rank how frequently you apply the following feeding strategies during times of moderate to severe shortage

Feeding strategies	Rank
1. Send camels to “*forra*’ (satellite) camps	
2. Rent/lease grazing pastures	
3. Split the herd by classes for preferential feeding	
4. Purchase of more commercial feeds	
5. Use my own cultivated forages	
6. Use more of non-traditional feeds	
7. Prolong daily grazing time	

3 = Most frequent practice; 2 = Frequent but not the most practice; 1 = Less frequent practice

0 = Not a practice at all.

F. Herd Structure and breed preference

1. Record the total number of all camels in the herd of the different classes:

Classes	Males	Females
1. Calves before weaning		
2. Immatures		
3. Adult (Breeding)		
4. Castrates		
TOTAL		

G. Camel market values

Record information regarding camels sold in the last 12 months

Class of camels	Total No. sold	Reasons for selling	Sold where	Average price (Ksh)
1. Heifers				
2. Steers				
3. Adult females				
4. Adult males				

Reasons for selling

1. Disease
2. Old age
3. Feed shortages/ destocking
4. Poor performance (production, reproduction)
5. Cash for emergencies
6. Cash for other investment

7.N/A

Where sold

1. Isiolo market
2. Markets outside Isiolo
3. Neighbouring farmers
4. Direct to butchers
5. Other (Specify)
6. N/A

2. Record information regarding camels purchased into the herd in the last 12 months

Class of camels	Total No purchased	Reason for Purchase	Where Purchased	Average Price (Ksh)
1. Heifers				
2. Steers				
3. Adult females				
4. Adult males				

Reasons for purchase include

1. Breeding
2. Rear and then sell
3. Cheaply available
4. Others (specify)
5. N/A

Where purchased

1. Isiolo market
2. Outside Isiolo market
3. Neighbouring farmers
4. Others (specify)
5. N/A

H. Milk off take estimates

1. How many times do you milk your camels per day during each of the following seasons?

Wet season	Dry season	Drought periods

2. Randomly select (some) lactating camels and record information below:

Camel ID or Name	Breed	Present parity	Average milk yield per day (in litres)		
			At calving	Mid lactation	At drying off
1					
2					
3					

Breed: 1 = Somali; 2.= Rendille/ Gabbra; 3 = Turkana; 4 = Pakistan

3. Estimate the daily total milk offtake, total consumed at home and total sold during the different seasons

	Wet season	Dry season	Severe Dry period (Drought)
Total herd offtake (litres)			
Total consumed at home (litres)			
Total sold (litres)			

I. Milk marketing

1. Record the following information regarding milk marketing:

Main buyer category	Average distance to selling point (Km)	Mode of transport used	Milk price (Ksh /litre)	Nature of payment

Buyer category	**Mode of transport**	**Nature of payment**
1. Individual consumers	1. On foot	1. Direct cash
2. Milk traders	2. Bicycle	2. Contract arrangement (e.g monthly)
3. Hotel/ offices	3. Donkey	3. Other (specify)
4. Milk processors	4. Camels	
5. Cooperatives	5 vehicles	

2. Estimate the average revenue (income) that you get from selling camel milk **per month** during the different seasons (in Ksh).

Wet season	Dry season	Drought periods

How do producers / traders test for milk quality?

Colour

Taste

Modern methods

Other (specify)

J. Disease incidences

1. What are the 3 most important camel health problems in your herd (in order of importance):

Most important (3)	Moderate importance (2)	Low importance (1)

NB: use local and/ or scientific names

2. When are these diseases (health problems) most frequent in your herd?

Disease ranked (Names)	Wet season	Dry season	Drought periods	All seasons
3 =				
2 =				
1 =				

1= yes;

2= no

K. Extension and Veterinary services

1. Indicate availability, source (who provides) and topics discussed for extension and veterinary services.

	Extension services	Veterinary services
Availability		
Source (provider)		
Topics / case		

Availability	**Source (provider)**	**Topics (cases)**
0= not available	0= none	0= none
1= less frequently	1= Government	1= feeds/ feeding
2= more frequently	2= NGO/ project	2= breeding
	3= private provider	3= calf rearing
	4= neighbouring farmer	4= "Boma" management
	5= radio	5= fertility
	6= TV	6= market for camel and camel products
	7= Extension leaflets	7= treatment of disease
		8= control of diseases
		9= Destocking
		10= environmental problems of camel production

Appendix 2: Structured interview guide for pastoral camel production system in Isiolo County, northern Kenya

Questionnaire number ____

Enumerator's name ____

Date of interview DD _______ MM _______YEAR____ Location________________

A. Herd owner/respondent characteristics

Personal details of herd owner/respondent.

Particulars/characteristics	Herd owner/respondent
1.1 Name	
1.2 Gender: 1 Male 2 Female	
1.3 Age (in years)	
1.4 Ethnic affiliation	
1.5 Educational level	
1.6 Major occupation	

Ethnic affiliation	Education level	Major occupation
1. Boran	0. No formal education	1. Livestock keeping
2. Somali	1. Primary level	2. Business
3. Turkana	2. Secondary level	3. Formal employment
4. Gabbra	3. Post secondary college	4. Others (specify)
5. Rendille	4. University level	
6. Others (specify)		

B. Camel ownership and production objectives

1. Rank the importance of different sources of livelihoods to your household's needs:

Camels	Cattle	Sheep &goats	Business	Formal employment	Crop farming	Remittances from relatives

3 = Highest importance; 2 =Average importance; 1 = Low importance; 0 = No importance

2. Was your first/foundation herd acquired through? [ ]

Inheritance from family

Purchase

Both inheritance and purchase

3. Rank the relative contribution of each of the following uses of camels to your household's needs:

	Rank
1. Sale of milk	
2. Sale of offspring (Progenies)	
3. Use for transportation needs	
4. Socio-cultural needs (e.g. paying dowry, slaughter for ceremony)	
5. Receive cash from recreation (e.g. riding, racing)	
6. Keep as form of wealth	

3 = Highest importance; 2 = Average importance; 1 = Low importance; 0 = No importance

4. Herd size (total number of camels in the herd):

	No. of camels
Owned by the household	
Kept but not owned by the household	
Total number of camels in the herd	

5. How did the recent (2006) **drought** affect your livestock?

Species	Number died	Number survived
1. Camels		
2. Cattle		
3. Sheep		
4. Goats		

C. Camel management systems

1. State the camel management system you practice **presently** (i.e. now):

1 = Pastoral only; 2 = Pastoral and sedentary combined; 3 = Sedentary only

2. Rank the reasons that make you practice this system of camel management:

	Rank
1. System is traditionally adaptable in this area	
2. System allows easy movement in search of good pasture areas	
3. There is no alternative viable system	
4. Any other reasons (specify):	

3 = Highest importance; 2 = Average importance; 1 = Low importance; 0 = Not of any importance

D. Feed resources

1. Rank the importance of the following feeds for feeding your camel herd:

Types of feed resource	Rank
1. Native browses (Trees and shrubs)	
2. Native grasses	
3. Traditional plant roots, tubers and pods	
4. Others (specify)	

3 = Highest importance; 2 = Average importance; 1 = Low importance; 0 = Not of any importance

2. Name the forages predominantly grazed by camels during wet, dry and severe drought periods in this area:

Wet season	Dry/drought season
1.	
2.	
3.	
4.	

NB: Can use local names, but will be translated

E. Feeding strategies

1. How severe is the feed shortage in this area during the different seasons?

Wet season	Dry season	Severe Drought periods

3 = Shortage very severe; 2= Shortage moderately severe; 1 =Shortage low; 0 = No shortage

2. Rank how frequently you apply the following feeding strategies during times of severe feed shortage

Feeding strategies	Rank
1. Send camels to “*forra*’ (satellite) camps	
2. Split the herd by classes for preferential feeding (e.g. giving priority to lactating camels and calves)	
3. Use more of traditional dry season resources/feeds (e.g. roots, tubers, pods, etc)	
4. Purchase commercial feeds	
5. Prolong daily grazing time	

3 = Most frequent practice; 2 = Frequent but not the most practice; 1 = Less frequent practice
0 = Not a practice at all.

F. Herd Structure and breed preference

1. Record the total number of all camels in the herd of the different classes:

Classes	Males	Females
1. Calves before weaning		
2. Immatures (before breeding age)		
3. Adult (Breeding)		
4. Castrates		
TOTAL		

NB: Crosscheck with data given for **B** 4 on page 2.

G. Camel market values

1. Record information regarding camels sold in the last 12 months

Class of camels	Total No. sold	Reasons for selling	Sold where	Average price (Ksh)
1. Heifers				
2. Steers (up to 4yr				
3. Adult females				
4. Adult males				

Reasons for selling

1. Disease
2. Old age
3. Feed shortages/ destocking
4. Poor performance (production, reproduction)
5. Cash for emergencies
6. Cash for other investment
7. N/A (No sales)

Where sold

1. Within district market
2. Markets outside district
3. Neighbouring farmers
4. Direct to butchers
5. Other (Specify)
6. N/A

2. Record information regarding camels purchased into the herd in the last 12 months

Class of camels	Total No purchased	Reason for Purchase	Where Purchased	Average Price (Ksh)
1. Heifers				
2. Steers (up to 4 years)				
3. Adult females				
4. Adult males				

Reasons for purchase

1. Breeding
2. Rear and then sell
3. Cheaply available
4. Others (specify)
5. N/A

Where purchased

1. Within district market
2. Market outside district
3. Neighbouring farmers
4. Others (specify)
5. N/A

H. Milk production estimates

1. Estimate the amount of milk (in litres) produced per day for a random sample of 10 camels during the different seasons:

S/No	Breed	Parity (No of births)	Wet season	Dry season	Severe Drought periods
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Breed: 1 = Somali; 2 = Rendille/Gabbra; 3 = Turkana; 4 = Pakistan (NB: "0" milk yield means no data)

2. How do you test for milk quality (e.g. fresh, sour, normal or abnormal)?

Colour

Taste

Smell

Other (specify) ____

J. Disease incidences

1. What are the 3 most important camel diseases (health problems) in your herd (**in order of importance**):

Most important (3)	Moderate importance (2)	Low importance (1)

NB: use vernacular and/ or scientific names

2. By **ticking** against the appropriate season, indicate when the above camel diseases (health problems) are **most frequent** in your herd or area:

Disease ranked (Names)	Wet season	Dry season	All seasons (Anytime)	Other (specify)
3 =				
2 =				
1 =				

K. Extension and Veterinary services

1. How often are you visited by veterinary/extension staff?

1. = Never visited; 2 = Once a month; 3 = Once in 3 months; 4 = Once in 6 months; 5 = Once in a year

2. How are treatment and control effected for important camel diseases?

1. = Buy medicine from chemist and treat the sick animal personally
2. = Use traditional herbs
3. = Call traditional medicine man
4. = Other (specify) ____

3. Traditionally, what **human** ailments do you consider treatable by:

Camel milk ____

b) Camel urine ____