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Economic Analysis of Feeding Locally Formulated and Commercial Milk Replacer to Camel Calves in the Arid and Semi-Arid Lands of Kenya

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ABSTRACT

Despite the huge potential for the growth of camel herds, calf mortality remains a challenge among the pastoral camel keepers in Kenya. This is due to competition for milk by calves and households for domestic consumption and trade among other factors. Adoption of Commercial Milk Replacer (CMR) and locally formulated Plant Based Milk Replacer (PBMR) as an alternative to camel milk feeding has the potential of improving the camel calves' nutrition and household income. Ten camel calves were randomly assigned to two separate diets; PBMR and CMR, five in each diet, for 70 days. A control group of 5 calves on the pastoral milk feeding regime was also observed. Calves on PBMR were confined throughout the experimental period while calves on CMR were not confined but fed 2 litres of CMR daily. All the calves were weighed weekly. This study employed a Cost Benefit Analysis (CBA) to assess the financial viability of using PBMR and CMR as a replacement to camel milk. Costs which included milk replacer and labour were captured and extrapolated for ten years to show the benefits of PBMR over CMR. Net Present Values (NPV), a financial analytical tool that shows viability of each feeding regime was then calculated. The results showed that it is more economical to feed calves using PBMR (5) compared to CMR (3) or pastoral feeding regime (3). The study recommends promotion of PBMR among pastoral camel keepers for improvement of nutritional status of suckling camel calves and household income.

Keywords: Camel calves, Cost-benefit analysis, Mortality, Net present value, Nutritional status

INTRODUCTION

Camels play an important role in food and nutrition security because their milk and meat are rich in important nutrients for human health (Elhadi & Wasonga, 2015; Guliye et al., 2007; Hussen & Schuberth, 2021). Compared to other ruminants, camel milk is richer in minerals such as sodium, potassium, iron, copper, zinc, magnesium, vitamin C and important fatty acids,

proteins and enzymes, making it an important healthy option (Abrhaley & Leta, 2018). Camel production is a major source of livelihoods for many pastoralists in the Arid and Semi-Arid lands (ASALs) (Faraz et al., 2019b; Noor et al., 2013). The global demand for camel meat and milk is slowly but steadily rising owing to increased awareness on their nutritional and medicinal values (Abrhaley & Leta, 2018; Badawy et al., 2018; Faraz et al., 2019a; Mohammadabadi, 2021). The similarity of camel milk to human milk also increases its potential for use in infant nutrition (Berhe et al., 2017; Desouky & Salama, 2021). In the last decade, production of meat has increased by 40% while that of milk has been at 5% (FAO, 2021). Camel production statistics estimates show that Kenya had 4,721,900 heads of camel (KNBS, 2019), a growth from 2,864,732 in 2012 (FAO, 2021). Kenya comes in fourth in terms of camel population, after Chad (8,276,416), Somalia (7,243, 792) and Sudan (4,895,000) (FAO, 2021).

Feeding camel calf with milk replacer is a critical technology in improving productivity of the camel herds through supporting the lives of the vulnerable calves (Kertz et al., 2017). By unraveling the costs and benefits that accrue to this technology, a farmer can invest in the technology with the full knowledge of what to expect. Cost-benefit analysis presents a simple way of analyzing a technology. It shows financial and economic viability of an investment thereby enabling one to choose between options (Ng'ang'a, et al., 2020; Gittinger, 1982). Economic analysis has been applied by various scholars in different fields. To compare feeding regimes, Kaygisiz et al. (2007) compared piglets fed with sunflower seed meal (SFM) diet or soybean meal (SBM) diets, while the control groups were fed food wastes. Pillars et al. (2009) quantified the costs and benefits of implementing disease control programs on infected dairy farms using NPV and sensitivity analysis. To clearly show the viability of adopting such a technology whose full impacts may take a longer time to be realized, NPV tool is used to discount future values of the investments (Gittinger, 1982).

Research into the costs and benefits of using replacers formulated from locally available forages and other feeds ingredients is limited. The main objective of this study was to fill this gap in knowledge and provide information on costs and benefits of alternative feeding regimes for camel calves in ASALs of Kenya. This involved use of milk replacers formulated using locally available feed ingredients compared to commercial cow calf milk replacers and conventional pastoral milk feeding regime and management practices for suckling camel calves.

METHODOLOGY

Study Area

This study was conducted in Marsabit County, Karare ward situated between latitude 02^{o} 45^{o} North and 04^{o} 27^{o} North and longitude 37^{o} 57^{o} East and 39^{o} 21^{o} East. The County lies in four main ecological zones, namely, sub-humid, semi-arid (mainly woodlands), arid (predominantly bushlands) and very arid (scrublands), therefore classified as an Arid and Semi-Arid Land (ASAL). Rainfall is bimodal with long rains coming between April and May while short rains come between November and December, with rainfall ranging between 200mm and 1000mm. The main economic activity is livestock keeping and cross border trade. In ASALs of Kenya, livestock contributes over 90 percent of employment and household incomes (Nyariki & Amwata, 2019). Karare ward was purposively selected due to presence of enough camel calves for the feeding trials in one herd and also being in a peri-urban camel production system, where camel milk is sold in Marsabit town on daily basis. Peri-urban production was considered

because of limited camel herd mobility which allowed for smooth running of the field experiments.

Data Collection

This study combined qualitative and quantitative data. First, key informant interviews were conducted to gain familiarity with the pastoral systems in the area of interest. The household survey was conducted in Karare ward, which has an estimated 886 households (KNBS, 2019). To obtain the sample, the formula for finite populations was adopted (Kothari, 2004).

$$n = \frac{z^2.p.q.N}{e^2(N-1)+z^2.p.q} \quad (1)$$

Where, n is the size of the sample and N is the size of the population, e is the acceptable error assumed to be 5 percent, z is the standard variate at a 95 percent confidence level, p is the sample proportion which is assumed to be 95 percent and $q = 1 - p$

$$67\ households = \frac{1.96^2.(0.95)(0.05)884}{0.05^2(884-1)+1.96^2(0.95)(0.05)} \quad (2)$$

An additional 13 households were added to the required sample to cater for any gaps during the interviews adding up to 80 household units. Subsequently, a cross-sectional survey was conducted on the pastoral households to collect primary data using semi- structured and pre-tested questionnaires. These questionnaires captured cost structures and socio-economic characteristics of camel keepers in the study areas. Focus group discussions (FGDs) comprising of 12 persons per group were also conducted in the study site to gain a deeper understanding of camel production and calf mortality. Local feed resources used for calf supplementation by pastoralists during the dry and wet seasons were identified. Preferred forages used for supplementation for calves while in pen confinement were also identified and ranked. The top 10 plant species were then sampled for laboratory analysis.

Proximate composition of the samples was done to determine dry matter, crude protein and minerals. The best plants in terms of nutrients, such as protein, energy and minerals were used as ingredients of plant-based milk replacer. The following ingredients were used to constitute plant-based milk replacer; *Acacia tortillis* pods*, balanites aegyptiaca* fruits, *Grewia bicolor leaves, Lannea schweinfurthii* leaves, maize meal, premix (minerals and vitamins), and molasses. Fifteen growing camel calves, 3 months old, of Somali breed and their crosses with Rendille and Turkana camels weighing approximately 102.3 Kg ±1.3 (mean±SE) from Marsabit County were randomly assigned to plant based milk replacer (PBMR**)** and commercial milk replacer (CMR) from Unga feeds limited (Afya bora milk replacer) diets in a completely randomized block design. Five unconfined camel calves on pastoral camel milk feeding regime were used as control.

Estimation of Cost and Benefit

Cost benefit analysis aims at providing a consistent way of evaluating alternatives for the purpose of decision making (Pillars et al., 2009). The cost of each component used in the formulation of milk replacers was estimated and quantified using local currency. The cost of CMR was valued at local retail market price while the cost of camel milk was valued at farm gate price. The value of a camel calf was estimated at the market value. Further economic analysis was also done using NPV, BCR and Sensitivity Analysis. NPV was estimated using the formula:

$$NPV = \frac{C_t}{(1+r)^t} \quad (3)$$

where NPV is the Net Present Value, C_t is the net cashflow at time t, r is the discounting rate which varies depending on the market environment and t is the time of cash flow (Gittinger, 1982; Khan, 1993). The BCR is calculated by finding the ratio between discounted total benefits and discounted total costs. A positive NPV indicates that it is worth investing in the technology and vice-versa. Further to this, different scenarios are modeled to represent different feeding regimes and situations that inform a farmer on risks that they may expect in the investment (Kashangaki & Erickson, 2018). For camel milk replacers, data on costs and benefits derived from three alternatives which included i) the pastoral system ii) use of commercial replacer and iii) a locally formulated milk replacer were collected. These would provide clear and plausible alternatives that farmers can adopt in improving the nutrition of camel calves.

RESULTS AND DISCUSSION

Cost of Camel Milk Replacers

One of the most important aspects of cost-effectiveness in feeding animals is affordability of ingredients used in formulating the feeds. This is largely because feeds take up a substantial percentage of total costs in livestock management. In Africa, dairy feed costs could contribute to 50-70% of total milk production costs (Alqaisi et al., 2011). In Kenya, camels are grazed in communal lands, meaning that herding costs are higher and may contributes to over 60% of camel production costs (Kuria et al., 2016). Milk replacers are important to the well-being of the camel calves and to the sustainability of the herd in households where camel milk is used for home consumption and trade.

This study focused on three feeding regimes; firstly, PBMR was formulated using locally available materials collected from the local environment, with some additional bought ingredients. These included *Acacia tortilis* pods*, Balanites aegyptiaca* fruits, *Grewia bicolor* leaves, *Lannea schweinfurthii* leaves, maize meal, premix, and molasses. *Acacia tortilis* pods have been shown to have a positive effect on lactating camels by increasing available milk and calf weight (Sagala et al., 2021). Secondly, CMR is an already a formulated commercial replacer, readily available in the selected agro-vet shops. Two kilograms of the CMR diluted in 12 litres of water is enough to feed 5 camel calves per day. The average cost per kilogram of CMR is KES 87.00. Lastly, the pastoral system which was the control for this study, did not incur replacer costs because the calf generally suckled an estimated two litres from the dam daily till it is weaned. The ingredient composition and cost of replacers are presented in Table 1.

Table 1: Composition and Cost of Local Milk Replacer (PBMR)

Ingredients	Quantity (kg)	Unit price	Total cost (KES)
Acacia tortilis pods	224	5.9	1328
Maize meal	140	28	3920
Premix	10	250	2500
Molasses	120	15	1800
Grewia bicolor	434	5.9	2574
Lannea schweinfurthii	420	5.9	2491
Balanites fruits	140	5.9	830
Total	**1488**	**10.37**	**15443**

The pre-ruminant calves from birth to 3 weeks are usually fed with liquid feed in the form of whole milk or milk replacers formulated from milk by-products. At a later age, milk replacer formulations can have substantial portion of milk proteins replaced by alternative protein sources of feed origin. By three weeks, the rumen fermentation begins, and then formulated solid feeds of higher digestibility can also be offered as a substitute for whole milk (Kertz et al., 1984). Ingredients in milk replacers can vary widely and are most commonly milk or plant based. The later formulations are less expensive, but milk proteins are much more digestible for young calves. The commencement of feeding with CMR can be done after 7 days of colostrum feeding or later till the calf is weaned (6 months). Estimation for the period the calf is fed on replacer is 183 days. During this period the camel calf is fed on PBMR or CMR, and the benefit received is the amount of milk saved by the household.

In the pastoral systems, where this study is based, the communities tap onto free resources available in the environment. These resources include communal lands, pastures, water and in this case the natural occurring ingredients for the PBMR. These resources are not easy to cost due to the nomadic nature of pastoral management systems. The table below depicts a case scenario for costing PBMR assuming no labour costs are incurred to collect the ingredients.

Table 2: Composition of milk replacer assuming zero labour costs

Ingredients	Quantity (KG)	Unit price	Total cost (KES)
Acacia tortilis pods	224	0	0
Maize meal	140	28	3920
Premix	10	250	2500
Molasses	120	15	1800
Grewia bicolor	434	0	0
Lannea schweinfurthii	420	0	0
Balanites fruits	140	0	0
Total	**1488**	**5.5**	**8220**

The table above shows that the cost of PBMR without labour costs is almost halved. This assumption is based on the practice that herders collect these ingredients as they manage the camels on a daily basis. This cost is covered in the monthly labor cost for the herders.

Labor Costs

Labor costs for this study included the cost of collecting locally available materials used in formulating PBMR, feeding and taking care of the calves. For CMR, labor costs constituted feeding and taking care of the calves. For the experimental research, KES 200 per day was incurred for 70 days for the 10 calves under CMR and PBMR. This figure was then extrapolated for 183 days, the number of days before the calves are weaned. For every year that calving is experienced, it is assumed that the same additional labour cost will be incurred for calves under CMR and PBMR. For the pastoral system, lesser labor costs were incurred because the calves were left at the family villages/*manyattas* and were fed by those left at home till the calves are strong enough to browse in communal rangelands. In this study however, daily cost of labour under pastoral regime was estimated at average cost of KES 178, obtained from survey of pastoral farmers. This is the extra labour costs assumed to be incurred each year when calving takes place.

Veterinary Costs

These were calculated from administration of drugs during experimentation and from estimations from data collected for this work on general camel management practices. Veterinary costs were incurred across all feeding regimes. However, without the use of a milk replacer, it was noted that there were additional costs of treatment incurred for the calves.

Water Costs

Water is an important cost component for livestock production in the ASALs. While camel water requirements may not be as high as the other livestock, the immobility of young calves meant that water had to be provided at an accessible point. Water cost did not vary across the three regimes. Majority of the households incurred monthly water charges for all the animals kept on the farm. For the purpose of the study, KES 2,500.00 was used for both the camel calves under PBMR and CMR, for the 70 days. This figure was then extrapolated to illustrate the costs for 183 days. Under the pastoral regime, an average of KES 2,643.00 was incurred per month as cost of water. Considering that this figure was incurred for an average of 28 camels in a herd, for this analysis, it was assumed that this figure varied with the size of the camel herd. From this, an estimated cost of water per camel in the pastoral regime was estimated.

Milk Saved

The results of the study indicated that on average a calf is fed on 2 litres of camel milk per day. When the camel calf is fed on milk replacers, then the camel milk saved is available for either human consumption or the market. The use of milk replacer therefore allowed the farmer to earn an extra income from sales of milk saved. When the calf is left to suckle, as is the case under pastoral regime, then it was assumed that no milk was saved. The average cost of a litre of camel milk was estimated at KES 120.00 per litre in Marsabit town. The benefit of milk saved was assumed to be only during the years when there was calving.

Total Value of Calves in Herd

Based on literature (Isako et al., 2020), a mortality rate of 24 percent was used to calculate the value of herd for CMR and PBMR feeding regimes while 35 percent mortality rate for pastoral systems (Tura et al., 2021) to derive surviving herds. Market prices for camel calves through the years were used to derive the value of calves as they matured. A higher mortality rate reduces the number of surviving camel calves and vice versa. Apart from mortality rates, herd size also varies depending on the calving interval and calving rates and the number of female calves born. For this study, a calving rate of 80 percent calving interval of 2.5 years and 50 percent chance of a calf being born female was assumed.

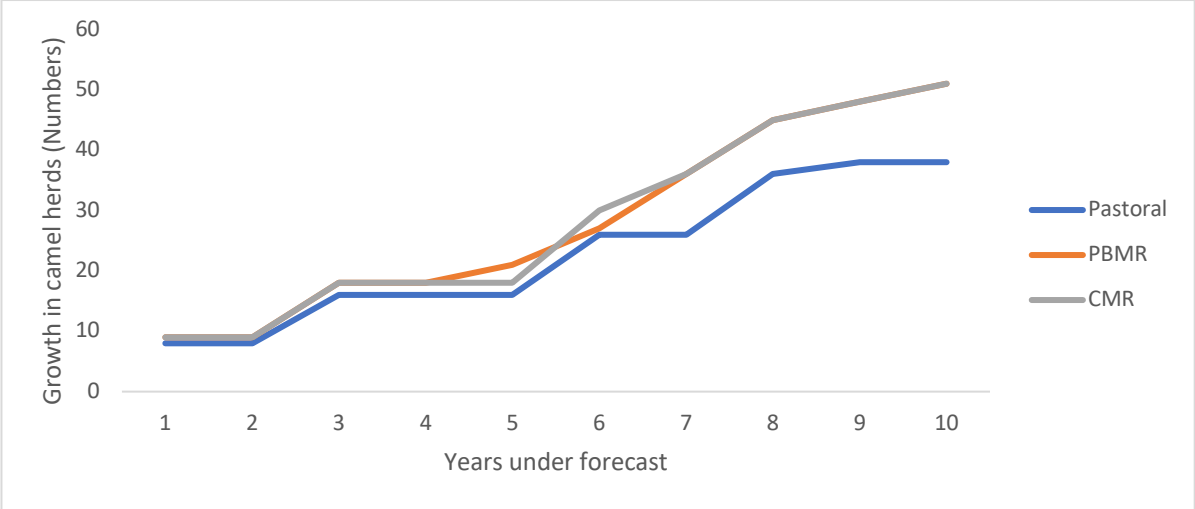


Figure 1: Chart showing growth in camel herds in the three regimes

Results as presented in the chart above (Figure 1) indicate that although there was increased growth of the herd under the three feeding regimes, in the long run, it is under PBMR and CMR that the camel herd grows at a faster rate. The effects of milk replacers on calf mortality and herd growth therefore accrue in the long term.

The results presented in Table 3 show the socio-economic characteristics of the sampled pastoral households. The average age of the household head was 50 years, while 75 percent were male- headed households. The majority of the household heads had no formal education (86 percent). The main economic activity was livestock rearing even though some sampled households had other income generating activities. A majority also did not use milk replacers in feeding their calves (89 percent) while 90 percent indicated to have experienced diseases among camel calves in the year before the survey. Indeed, the data further showed that among the pastoral systems, mortality among calves was a key challenge, 61 percent indicated to have lost a calf in the past year.

Table 3: Socio-economic characteristics of sampled pastoralist

Variable	**Observations**	**Mean**	**Std. Dev.**
Age of household head (years)	80	50.075	14.90032
	Variable	**Frequency**	**Percentage**
Gender of Household head	Female	20	25
	Male	60	75
Household head's education level	None	69	86.25
	Primary	4	5
	Secondary	3	3.75
	Tertiary	4	5
Main economic activity	Livestock only	57	71.25
	Livestock and Business	11	13.75
	Livestock and salaried	12	15
Use of milk replacer on calves	No	64	80
	Yes	16	20
Calf affected by diseases in 2020	None	8	10
	Yes	72	90
Calf died in 2020	None	31	38.75
	yes	49	61.25

Livestock Characteristics

Livestock characteristics as shown in Table 4 reveal that the sampled pastoral households had diversified livestock enterprises. Besides camels, the pastoralists also kept sheep, goats, cattle and chicken. Indeed, this is a key characteristic of the pastoral communities that enables them cope with various risks. The households had an average of 28 camels, 24 heads of cattle, 40 goats, 31 sheep and at least 3 chickens.

Table 4: General livestock characteristics in the sampled pastoral system

Variable	Observation	Mean
Sheep	80	31.3
Goats	80	40.5
Chickens	80	3.3
Cattle	80	24.4
Camel	80	28.2

Camel herd characteristics (Table 5) show that on average, the sampled households had 2 camel bulls, 3 castrated, 5 camel calves, 4 dry camels and 6 lactating camels. The average age for a calf to reach reproductive maturity is estimated at 5 years with an average calving interval of 2 years. This is consistent with Bakheit et al. (2016) and Gherissi et al. (2020) who reported that camels had a calving interval of 18-24 months and an age at first calving of 48 - 54 months. The results further indicate a difference in the value of a female and male calf. A female calf of one year was valued (KES 37,630.00) while a male calf was estimated at (KES 22,000.00).

Table 5: Camel herd characteristics in pastoral system

Variable	Observation	Mean
Camel bulls	80	2.28
Camel calves	80	5.93
Dry camels	80	4.47
Lactating camels	80	6.03
Castrated bulls	80	3.55
Age to reproductive capacity	80	4.96
Average calving period	80	2.10
Price of male camel calf	80	23386.67
Price of female camel calf	80	37630.14

Cost Structures for the Pastoral Systems

Cost structures presented on Table 6 indicate that camel calves in the pastoral regime depend on camel milk from birth to weaning age. Since pastoral camel farmers move from one place to another in search of pasture and water, nutritional needs of the calves are negatively affected when dams travel for long distances leaving the calves within the homesteads.

Table 6: Cost structures in the pastoral systems

Variable	Observation	Mean
Monthly wages	80	5444.26
Treatment cost	80	2717.72
Daily milk produced per camel (Litres)	80	3.43
Home camel milk consumption (Litres)	80	2.84
Amount fed to calve (Litres)	80	2.64
Milk available for sale (Litres)	80	3.98
Monthly water cost (KES)	80	2643.53

From the costs obtained in pastoral regimes however, it is difficult to separately estimate the costs attributed to young calves alone since they are incurred for the whole herd. The average cost of labor is estimated at KES 178.00, while monthly wage is KES 5444.00. The monthly cost of treatment of common diseases and acaricide was KES 2,700.00. The amount of camel milk fed to calves was estimated at 2.6 litres per day, while an average of 1 litre was sold and another 1 litre was consumed by the household.

Economic Comparison of Commercial and Plant Based Milk Replacer

Cost benefit results (Table 7) were obtained from 5 camel calves fed on PBMR, 5 on CMR and 5 in the normal pastoral system that depended on suckling camel milk.

Table 7: Economic comparison of feeding camel calves on PBMR versus CMR and pastoral regimes

	PBMR	**CMR**	**Pastoral**
Costs	KES	KES	KES
Cost of local replacer	19,215	79,605	-
Water	12,200	12,200	12,200
Labor costs	32,574	32,574	18,000
Veterinary cost			3,400
Total cost	**66,615**	**127,005**	**33,600**
Benefits			
Milk saved	219,600	219,600	-
Veterinary cost saved	1,850	1,850	
Number of calves	5	5	5
Number of surviving calves with replacer *(*24% with replacer, 35% without*)*	4	4	3
Value of calf	35,000	35,000	35,000
Total value of calves in the herd	133,000	133,000	113,750
Total benefits	**354,450**	**354,450**	**113,750**
B-C	287,835	227,445	80,150
BCR	**5**	**3**	**3**

The cost of feeding and maintaining the 5 calves under each regime per day was captured and a total cost for 6 months was then estimated using costing techniques. The daily cost of labor and water, did not vary during the entire experiment period. Subsequently, under the PBMR regime, the cost of collecting plant-based materials is assumed not to vary during the 6 months' period. Also, the price of CMR did not vary, since the market value remained constant during the study period. Veterinary costs were captured when they were incurred during the experimental period and the same was estimated for a 6-month period. Analysis therefore was based on costing theory by calculating costs, average costs and total costs. These costs then incorporated in the CBA to estimate the overall BCR for each regime. For this study, the main benefits were obtained from milk saved when replacers were used in place of camel milk and the value of the calf.

The results of the study indicated that it was more profitable to use the PBMR when compared to the CMR as shown by the higher benefits versus costs (Table 6.7). PBMR was compounded from plant materials collected locally, hence the main cost incurred was the cost of labor for collection. The CBA analysis shows that the benefits from using PBMR is greater than the other

two regimes. The difference emanates from the cost of buying the CMR which was higher compared to the cost of formulating PBMR. Under CMR and PBMR, the benefits included reduced mortality which were captured by the value of the calves saved. The reduced mortality rate in calves fed on the CMR and PBMR was attributed to the improved immunity that resulted from using milk replacers. Feeding the calves on milk replacers increased the availability of camel milk for sale and (or) consumption in the household. The results indicated that there was a higher benefit- cost ratio for PBMR (5), verses CMR (3) and pastoral system (3). From this analysis, every shilling invested in the PBMR technology, 5 shillings was generated compared to 3 shillings in both pastoral and commercial regimes. The positive BCRs for the three regimes showed that they are all profitable and are operating above the break-even points. However, the PBMR represented a better regime compared to the other two. This generally showed that while the pastoral system was a low input regime, more can be gained from tapping and utilizing the freely occurring local resources.

Given a camel calving rate of 80%, Table 6.7 shows a projected benefit cost scenario of the three regimes over a 10-year period. This estimation was based on the assumption that a calf once born uses milk replacers for the 183 days (6 months), after that it is allowed to move with the herd. When compared to CMR, PBMR was cheaper, thus farmers will have a higher chance of consistently feeding the calf as recommended. This improves the calf's immunity and reduces mortality. With a calving interval of 2 years, it was estimated that at year 3 the dams will have additional calves. Additionally, a calf is expected to reach maturity by the age of 5 years. With an estimated 80 percent calving rate, the herd will increase. Improved feeding can thus contribute significantly to increase in herd size.

Even though majority of previous studies had valued increase in weight as a benefit (Sagala et al., 2021), this study used the value of calf herd and milk saved as the benefits. The nature of camel pastoral production is unique since pastoral camel keepers hardly slaughter their camel calves for meat. Females are incorporated into the breeding herd while the males may be slaughtered at maturity or selected as breeding bulls/stock. Majority of farmers keep small ruminants for the purpose of slaughtering and daily family subsistence.

Table 8: Comparison of Feeding Regimes on the 10th year of Projection

Economic variables	PBMR	CMR	Pastoral
	Y10	Y10	Y10
Total value of calf herd	3160348	3,160,348	2,286,627
Benefits *less* costs	3,209,497	3,161,185	2,188,913
NPV	1,033,372	1,017,817	704,771
Discounted benefits	1,074,112	1,074,112	736,233
Discounted Costs	40,740	56,295	31,461
Size of camel herd	51	51	38

Table 8 shows NPV estimates with 15 dams, which was the average number of dams in a herd per household in the sampled baseline study. NPV showed that keeping camels is profitable to the pastoral camel keepers as shown by the positive NPV across the three feeding regimes. The difference however lies in the higher benefit derived from milk saved and life of calves saved when milk replacers are used. The PBMR saved the farmer more because of its availability at cheaper prices compared to the CMR. The cost of CMR and PBMR is incurred every two-year interval based on the assumption of a two-year calving interval and that all 15 dams calve down

in year one. The cost will also be incurred in the fifth year when the calves mature and start breeding. Comparisons of the regimes implied that promoting PBMR among pastoral farmers can have benefits in improving the income of camel farmers. The most important cost in PBMR feeding regime is the cost of labor incurred in collecting the ingredients and feeding the calves. Compared to the other regimes, the pastoral system is a low-cost regime reflecting the socio-economic situation of the pastoral communities in in the ASALs. Most of the costs were derived from water resource and veterinary costs for the camels. For this system, there was no extra milk saved, and therefore no gain for lack of adoption of this technology. Basically, most of the cost and benefit values for the local camel milk replacer and the commercial replacer were not different except on the cost of the milk replacer. The commercial replacer was more expensive (KES 43.50 per Kg) than the one formulated with local ingredients (KES 21.00 per Kg), giving the PBMR a financial advantage. Extra labour costs emanating from care given to the young calves are incurred seasonally during the calving periods. Similarity for CMR and PBMR is in the mortality rate which was assumed to be lower that of the pastoral system. This an important aspect in the sustenance of the camel herds and their profitability.

BENEFIT COST RATIO (BCR) COMPARISONS

Benefit Cost Ratio (BCR) is an important indicator showing the ratio of costs to benefits; a ratio of more than one implies more benefits attributed to the technology and subsequently those that accrue to a farmer when they adopt the same (Sassone & Schaffer, 1978). The graph below (Figure 2) compares the three regimes.

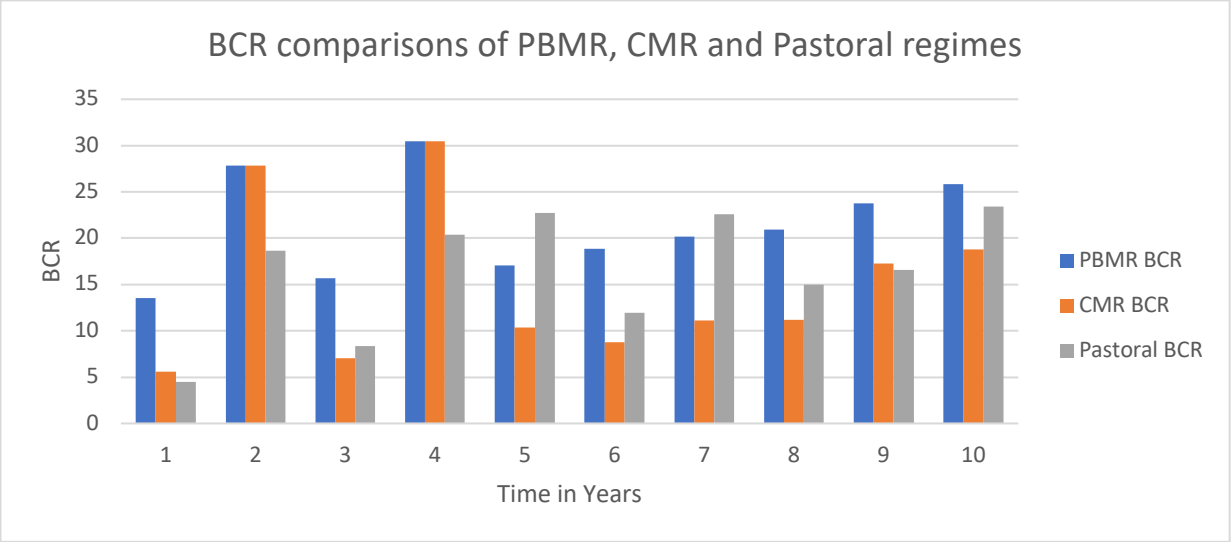


Figure 2: BCR under PBMR, CMR and pastoral feeding regimes

The BCR for PBMR shows a robust trend throughout the 10-year period under estimation; it is higher than CMR and pastoral regimes. In year five and seven however, BCR for PBMR is lower than the pastoral but still higher than CMR. This is because in year five and seven, the calves born at the start of year1 and year 3 have matured and have increased the number of lactating females. Thus the costs for milk replacers are higher when compared to the pastoral regimes. In the long run more benefits are realized from the PBMR regime.

Net Present Value (NPV) Analysis

The NPV is a financial analytical tool that shows viability of adopting a technology. The NPVs of the three regimes under analysis gave an indication of returns to the camel replacer technology if adopted. In light of increasing demand for milk and meat globally (Tadesse et al., 2012), the NPV is a tool that may help chose productivity enhancing technologies like the milk replacers. In decision making using NPV, the best option to select is the one with the highest NPV values. Comparison of the three regimes with a discounting rate of 12 percent showed that all the three regimes were positive, meaning that they were all profitable in the long run.

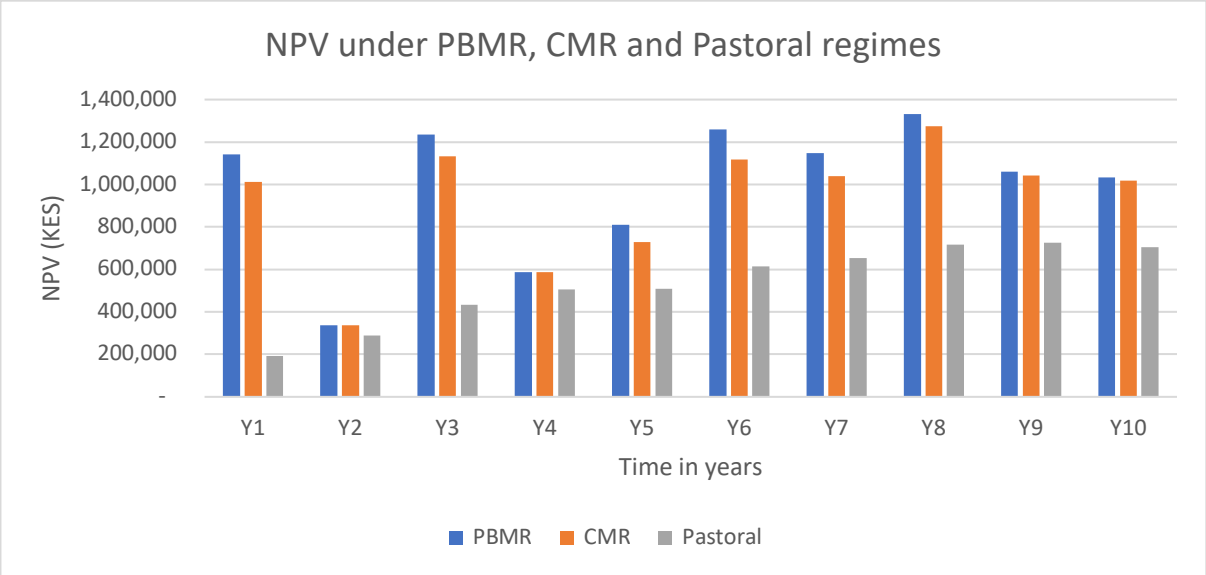


Figure 3: Chart showing forecasted NPV values for PBMR, CMR and Pastoral regimes

However, the PBMR yielded the highest return; therefore, it was more lucrative than the other two. The benefits that accrued to PBMR were greater, therefore availed more welfare benefits to the farmer.

NPV Under Varying Mortality Rates

Estimations for this study assumed a mortality rate of 24 percent for calves fed on the replacers and 35 percent for calves on pastoral systems (Tura et al., 2021). Other factors such as diseases, drought and management practices can also influence calf mortality (Ihuthia, 2010; Kamber et al., 2001). NPV scenarios were therefore developed to show the situation of camel farming should there be a decrease or an increase in mortality rates, assuming a constant discounting rate of 12 percent. Mortality rate was varied at 0, 20, 50 and 100 percent to show best and worst scenarios. When mortality rates were lower, the estimated future benefits were higher under PBMR as compared to the CMR. Although annual costs are important in estimating yearly benefits, the actual benefits are realized in year 4 to 5 when the calves have reached maturity age and start calving or can be sold for meat.

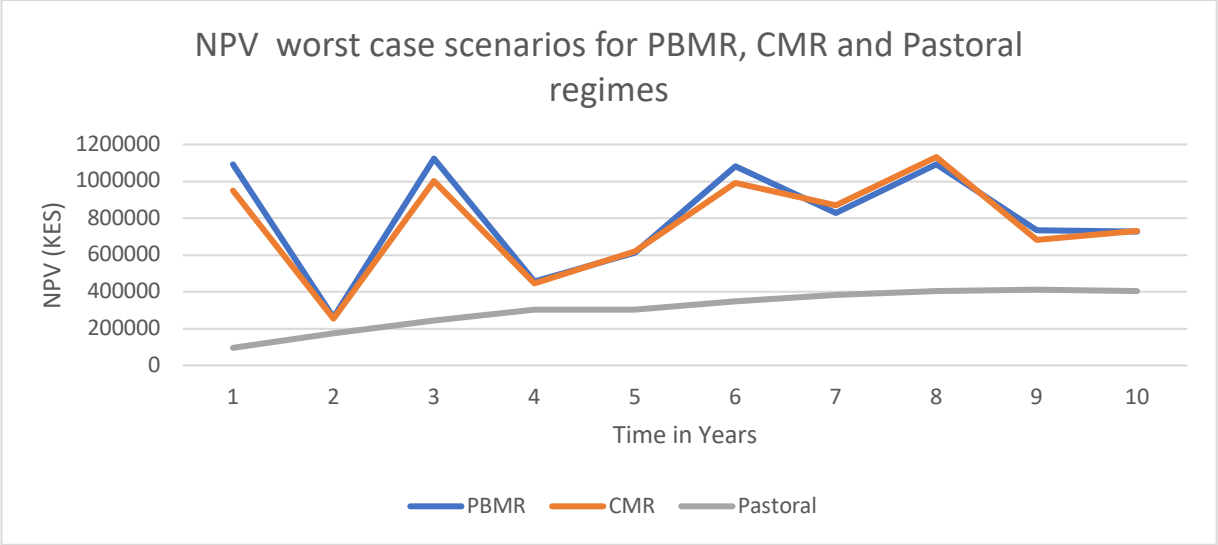


Figure 4: Chart showing worst case scenarios

Assuming a worse- case scenario (Figure 4) where mortality rate increased from 24-41 percent for PBMR and CMR and 35-60 percent for pastoral regimes, CMR and PBMR would still be profitable. This finding implied that in extreme situations such as severe droughts, using a milk replacer would be more profitable than not using one. Under extreme weather conditions, pastoralists have to travel even longer distances in search of water and pastures (Chinasho et al., 2017; Ndiritu, 2021). This implied that any supplementation for the calves is paramount to their survival.

Incremental Value Analysis

The chart (Figure 5), shows benefits derived from increase in camel herds estimates over a 10-year period.

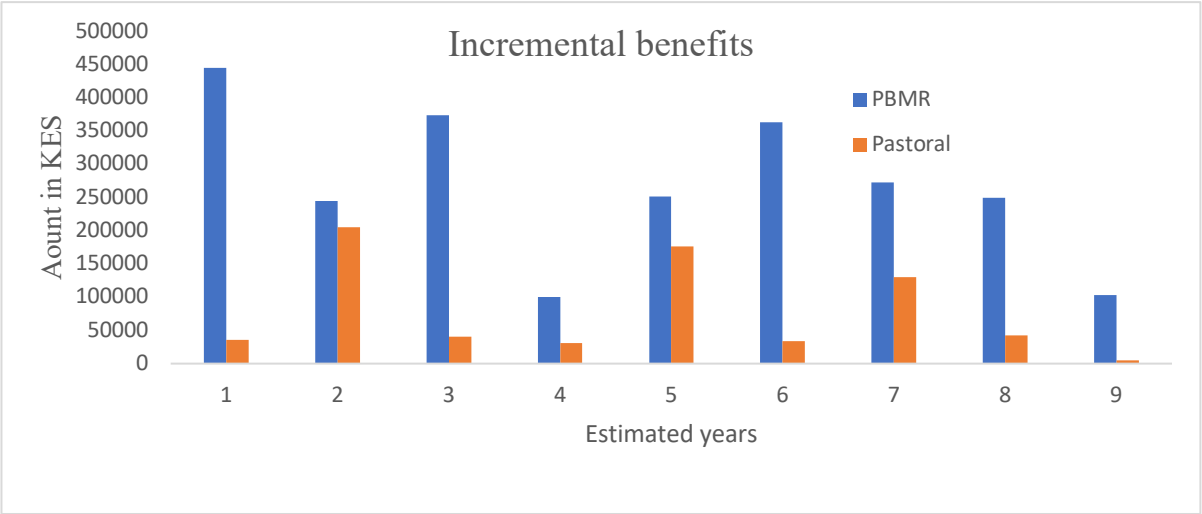


Figure 5: Chart comparing incremental benefits between pastoral and PBMR

Incremental benefits were obtained by estimating the change in value of the camels in the current year less the previous years' value. The value of the camel/ calf was obtained from market value given by the pastoral camel keepers. Once a calf is born, its market value increases

steadily till maturity. The value of mature dams increases two-fold since the calves born also give additional value. Incremental benefit also captures the value of milk obtained from milk saved with the use of PBMR. The costs captured were assumed to be incurred every year, indicative of the cash that pastoral camel keepers need to have to meet expenses. Figure 5 shows incremental benefits from PBMR and Pastoral feeding regimes where milk replacers were not used.

Even though the majority of pastoral farmers kept other animals which can be easily sold and slaughtered for cash purposes, this study assumed benefits and costs that accrued only to the camel enterprise. Under PBMR, the additional benefits less variable costs obtained are more, compared to the pastoral regimes. This implies that the sales from camel milk are enough to meet expected expenditure for the calves. By the tenth year, the benefits from pastoral regimes will hardly be enough to sustain expenses from the increasing herds. This finding shows that in pastoral systems camel farmers may not be making tangible losses, but may not be liquid enough to sustain the camel production business.

Sensitivity Analysis

Three important variables were considered in this analysis: an increase in prices of feeds, camel milk market prices, and discount rates. An increase in price of the replacer formulating ingredients is an important variable that may motivate or deter adoption of the milk replacers. While such a technology may improve productivity of the herd, increased prices mean higher cost of acquiring the technology, which may in turn discourage its adoption. This is because profitability is an important driver in enhancing productivity (OECD, 2015), and cost effectiveness of any technology is paramount in enhancing its adoption and use. In this study, prices of the PBMR were increased by 10%. The resulting NPV showed a slight reduction of 0.14 depicting that the local formulation may not be sensitive to prices.

Due to the increased demand of the camel milk, an increase by 10% in market prices of camel milk may be an important driver in increasing the welfare of the farmers. This is an important strategy that can improve productivity through market pull dynamics (USAID, 2020). Good market prices can attract more investments into the enterprises through the increased welfare gains emanating from participating in such markets. A sustained price would also mean that market push-pull dynamics can enhance not just the participation in the markets but adoption of productivity enhancing technologies such as the milk replacers, better milk handling practices such as cooling systems as well as better camel herd management practices. These practices in the long run bring about sustained herds and increased welfare of camel keepers. In this study, a 10% increase in prices of camel milk prices would improve the NPV by 3.43% in the PBMR regime. This is important for resource poor camel keepers who rely on the camels for cash flows to sustain their livelihoods.

The other important factor that this study considered is the discount factor. This enables camel keepers to understand the worth of the camel herds in present value terms. A camel enterprise is a long-term investment and operates under numerous risks. This factor enables the camel keeper to discern whether the opportunity cost of investing his money in a milk replacer is a worthy risk or not. The replacer is anticipated to improve the herd through reduced calf mortality and morbidity, and ultimately increased productivity. By investing their money in replacers, they forgo the opportunity to use or earn money in another enterprise (University of

London, 2009) such as in sheep and goats or cattle, which represents other important livelihoods for the community. A discount factor of 12% is the average lending rate of commercial banks in Kenya (Central Bank, 2021), and shows the cost of obtaining credit, which is an important driver in acquisition of technologies. Increasing a discount rate means that credit becomes expensive and therefore accessibility to the farmers becomes limited. In this study, the discount factor was increased by 10%. In both the pastoral regimes and the PBMR regime, there was a significant change in NPV values. There was a 6.0% decrease in PBMR regime, and 6.6% decrease in the pastoral regimes. This means that the pastoral systems may thrive better if macroeconomic policies that support credit access were enabled for the pastoral camel keepers. It also points to the importance of enabling institutions that provide credit to pastoralists to function optimally. Sound macroeconomic policies are important in enabling pastoral enterprises and generally the growth of all sectors of the economy.

Table 9: Variation of different parameters on NPV

Sensitivity Scenarios	Net NPV	% Change
PBMR 12% discount rate (Base)	9946394	-
PBMR with 10% feed price increase	9931483	-0.14
PBMR with 10% increase in milk price	10287219	3.43
PBMR with 10% increase in discount rate	9350783	-6.0
Pastoral with 10% discount increase	4,991,112	-6.6
Pastoral with 12 % discount (Base)	5,341,483	-

CONCLUSION

The CBA showed that PBMR has more benefit to the pastoral farmers in the short and long run when compared to the CMR. BCR analysis showed that PBMR is cheaper than CMR. Additionally, NPV analysis showed that there are more benefits that accrue to the farmers by investing in PBMR technology compared to CMR. The benefits of PBMR emanate from the use of cheaply available resources that can be harnessed by pastoral farmers. Promotion and investment in PBMR technology is therefore critical for its adoption and productivity enhancement in the camel herds. Adoption of this technology has the potential to stimulate environmental conservation for the plant species used in this technology.

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