The benefits of using calf milk replacers in calf rearing by smallholder dairy farmers in Kenya.

Student: Benjamin K Mungai - 3025734

Class: 4IDA – International Dairy Management

Coach: Hans Corten

Preface and Acknowledgements

The writer of this report is a student of Aeres University of Applied Sciences, Dronten undertaking a BSc Animal Husbandry in International dairy management course. I am currently on company placement at Nutreco Africa regional office in Boxmeer, the Netherlands undertaking internship work.

I wish to acknowledge with gratitude the enormous support and guidance that I have been granted by my thesis coach, Hans Corten. Similar gratitude is also extended to my university course coordinator Jantien Tempert who has supported and guided me since last year to date and her fellow colleague lecturers for imparting enormous knowledge and skills to me. In addition, I wish to thank my company coach Frans van Bohemen for the great support and guidance during the internship period. Lastly also I appreciate my colleagues for continuous support and also in availing requested information.

List of contents

Preface and acknowledgement 1

Executive summary 2

Chapter 1 Introduction 4

1.1 Dairy farming in Kenya 4

1.2 Dairy calf feeding 8

1.3 Calf milk replacers 9

Chapter 2 Materials and methods 10

Chapter 3 Results 11

3.1 Calf rearing feeding schedules/plans 11

3.2 Cost of feeding using whole milk and milk replacer 11

3.3 Comparing the costs of feeding 12

3.4 Consolidated benefits 13

Chapter 4 Discussion of results 15

Chapter 5 Conclusion 17

Bibliography 19

Appendices 22

List of tables

Table 1 the calf rearing feeding schedule 11

Table 2 the feeding cost of rearing calves using whole milk & milk replacer 12

Table 3Comparing the content and cost of whole milk & milk replacer 13

Table 4(a) Herd structure-old situation 14

Table 4(b) Herd size growth projection-old situation 14

Table 5(a) Herd structure-new situation 14

Table 5(b) Herd size growth projection-new situation 15

Executive summary

This thesis report is a product of a study undertaken to evaluate the benefits of rearing dairy calves using calf milk replacer among the Kenyan smallholder dairy farmers. The scope of the report focused on the main question which was to determine what were the economic benefits accruing from rearing dairy calves using calf milk replacer. It entailed undertaking literature review on scientific articles on studies undertaken on small holder dairy farming in Kenya and calf rearing using whole milk and calf milk replacers. Thereafter calculate the costs of rearing calves during the birth to weaning period, make a cost and content analysis of both feeding schedules and calculate a herd size growth projection.

In our findings, the conclusion was that it was significantly cheaper to rear calves using calf milk replacer at € 141.1 than when using whole milk at € 189.5 during the period birth to weaning. In addition our findings also concluded that there is increased growth in herd size in the long term with resultant effect of increased milk yields and gross farm income.

However, these economic benefits can only be realised by smallholder dairy farmers and remain feasible so long as the producer price of whole milk is higher than the price of calf milk replacer powder of equivalent amounts. Small holder dairy farmers must also adhere to the feeding schedule and reconstituting ratios as advised by the manufacturer or dairy advisor to realise better weight gain and growth.

1. Introduction

Kenya is a country situated in Eastern Africa. It borders Uganda in the west, Somalia & Indian Ocean to the east, Ethiopia in the north & and Tanzania to the south. Administratively Kenya is divided into 8 regions namely Nairobi, Central, Eastern, Coast, North-Eastern, Rift valley, Western & Nyanza and further into 47 smaller administrative Counties. The commercial and capital city is Nairobi. The country has a land area of 582,646 km^2, most (70 %) of which is arid and semi-arid land (ASAL) with low agricultural potential. It has a growing population of more than 45 million people with 3% annual growth (Kenya National Bureau of Statistics, 2017). The country has a varied climate ranging from warm and humid in the coastal area to cool temperatures in the highlands. Productivity potential can be divided into three categories;

- High potential areas receiving an annual rainfall of more than 850 mm;
- Medium potential, with annual rainfall of between 735 and 850 mm; and
- Low potential, with annual rainfall of less than 612 mm.

1.1 Dairy farming in Kenya

Livestock contributes 10-13% of total national GDP and dairy 4 % of the national GDP. Dairy production's role in Kenya's economy is its contribution to the livelihoods of the many people engaged throughout the value chain and to the nutritional well-being of many rural communities. The sector provides direct jobs to 1.2 million small holder dairy farmers to whom dairy farming is a source of income and food. The national dairy herd stands at 4.2 million dairy cattle producing 5.2 billion litres (Kenya Markets Trust, 2017; Kenya dairy board, 2012-2020). At the moment, the dairy production potential has not been fully exploited and has the potential to improve and contribute more to the national development goals.

Kenya's dairy industry at the moment is private sector driven. The current country total milk production is around 5.2 billion litres of which more than 70% of this total is produced by 1.2 million small scale dairy farmers. However there are a fast growing number of medium-scale farmers/investors who have invested in modern and commercial dairy production and a similar proportion remaining of large scale commercial dairy farmers. The total dairy herd size is estimated at 4.2 million dairy cattle consisting of purebred, crosses and upgraded local crosses indicating that their potential in milk production has not been fully exploited. (Kenya Markets Trust, 2017)

Large scale dairy farmers are commercially oriented and constitute more than 10% of the total number of Kenyan dairy farmers with dairy herds of 80+ lactating dairy cows and with farm sizes of more than 50 acres. Labour in these large scale farms is offered by hired employees with the head (manager) being a dairy farm professional. They have embraced automation which is confined to milking machines (rotary and herringbone type) and fodder production and feeding (use of tractors in planting, mowing & baling). The average milk

production realized per cow/lactation is 5000-7000kgs with some progressive farms especially those that have been on contract mating programme with the Kenya animal genetics and resources centre(KAGRC) registering more than 8000kgs (KAGRC, 2017; KLBO, 2017). These farms have been able to maintain 305 days lactation and are able to serve their heifers at 15 - 18 months thus attaining an age at first calving at 24-27 months. Large scale dairy farmers are located mainly in the milk sheds of Nakuru, Lessos, Trans nzoia, Kapsabet and Timau. They are reared in mixed Production systems i.e. dairy/cereals – wheat/maize/barley or purely dairy system. They are highly intensive with fodder production involving grass & lucerne paddocks for grazing and mowing for hay baling together with the growing of maize for maize silage making. They sell their milk to the milk processing companies under a mutually agreed milk supply contract which determines the price of milk, quantity, quality. Among the key challenges facing this category of farmers are the high costs of production due to high cost of feeds, supplements, credit etc.

Smallholder dairy farmers constitute the majority of the dairy farmers (70+ %) with farm sizes of 0.5 - 10 acres and a dairy herd of 1- 20 dairy cows. In this category, we have small scale dairy farmers who do it on subsistence level and another group of small scale dairy farmers to whom dairying is a source of livelihood who are the majority and of major interest to the report. Labour in most of these small scale dairy farms is provided by the immediate family members and is some situations casual labourers are hired. These categories of farmers produce milk on average per lactation 2500 – 4600kgs of milk per cow (Kimenchu, Mwangi, Wambugu, & Gitunu, 2014). They are situated in most high and moderate potential areas where they are organized and are members of dairy farmers' cooperative societies. Some of these big cooperatives societies like Githunguri , Mount Kenya, Wakulima dairy, Kiambaa , Muki, Ndumberi, Nyala and Lelan dairy societies among others are owned by small holder dairy farmers with some diversifying into milk processing , some into farm input stores and some like Wakulima and Mount Kenya into animal feed milling etc. Small holder dairy farmers are found spread in all the main milk sheds in the country (East African Dairy Development Programme, 2017). They rear in mixed Production systems i.e. dairy/tea or coffee or dairy/horticulture or dairy/food crops or purely dairy system. They are highly intensive with animals kept in zero grazing units or sheds. Fodder grown for the animals is mainly Napier grass and Rhodes grass for cut and carry purposes with maize being grown for home consumption whereas the dry maize stovers and crop residues are used for feeding the cows. Supplementation with dairy concentrates and or energy rich milling by-products is done as mostly the fodder available is not adequate. They market their milk through the dairy cooperatives and others to the milk traders. The cooperatives market the milk to milk processing companies who later sell processed products to consumers whereas milk traders sell the raw whole milk to consumers (East African Dairy Development Programme, 2017) (Ettema, 2016). The main challenge facing this category of dairy farmers is low cows' productivity in terms of milk yields and herd fertility, low fodder availability due to less acreage under fodder (Lanyasunya, Wang,

Mukirisia, & Abdulrazak, 2006), seasonal variations especially prolonged periods of drought, poor young stock management with high mortality rates and low daily weight gains. (Moran, 2011)

Dairy farmers rear their animals in dairy production systems that can be divided into three broad categories namely zero grazing(stall feeding), semi-zero grazing and open grazing. The zero grazing system is a more intensively managed system and cows are fed on rations that are relatively high in concentrates and stored forages. Semi and open grazing are more pasture-based systems, which are the primary production systems in several dairy producing units in the country. The choice of the feeding system is normally motivated by a desire to optimize the limiting resource. For example, in areas of high population density, land tends to be the limiting factor whereas in open grazing, labour is the limiting factor. In semi-zero grazing, producers use a combination of zero and open grazing systems, which is appealing in that it reduces costs, but still allows the feeding of concentrates to improve milk production levels. Purchase of concentrates forms the largest cost component among farms practicing zero and non-zero grazing systems. The cost of maintenance and repairs is the next largest expense in the zero grazing system, while it is labour in the non-zero grazing system (Tegemeo institute of Policy Analysis and Research, 2011).

Dairying farming is heavily concentrated in parts of Eastern, Central and Rift valley regions where thirteen milk sheds (areas within a 35 kilometres radius producing between 50,000 – 100,000+ litres of milk per day) have been identified. These areas are Timau, Meru, Embu, kabete, Gatanga, Nyeri, kinangop, Ol kalou, Sotik, Nakuru, Kapsabet, Lessos and Trans nzoia. These areas have high livestock density which in turn means there is a high milk density threshold per square kilometre. They are within high rainfall areas or in close proximity to areas with high fodder/forage production.

The provision of dairy farm inputs mainly dairy concentrates, mineral supplements, drugs and vaccines, advisory and extension services, credit and financial services have mainly being offered by the private sector (Rademake, Bebe, Lee, & Kilelu, 2016) . However in recent times some well-established dairy societies have taken up services like farm input stores from where dairy farmers are able to access dairy farm inputs on demand and also given on credit based on their milk volumes delivered. Wakulima dairy farmers cooperative society in Nyeri county among others did put up an animal feed mill and have started the manufacturing of dairy animal feeds (concentrates) for their members. The marketing of milk has evolved over time with currently more milk (about 60%) being handled by milk traders, about 35% by cooperative societies who bulk, chill and sell to milk processing companies. Presently Kenya has about 30 active milk processors; Brookside dairies, New KCC limited, Githunguri dairy farmers cooperative society and Sameer limited being the largest ones processing together about 85% of the 1.5 million kilograms of milk processed daily (Ettema, 2016).The market leader is Brookside dairies Ltd after it merged its operations

with smaller companies like Tuzo Spinknit limited, Molo milk limited and Delamere dairies ltd.

This increased demand of milk has been fuelled by the increasing urbanization (migration of more people to urban centres for jobs) and with a population of 45 million people growing at an annual rate of 3 % being witnessed in the country which has resulted in increased milk consumption with a current per capita consumption of 110 litres per year, the highest in the region. More consumer demand for full cream milk has led to the growth of milk dispensing machines in major towns while the demand of dairy value added products is also driving the demand of dairy farmers to produce high quality milk (Kenya Markets Trust, 2017). This increasing demand for milk is encouraging farmers to seek ways to improve milk production by seeking access to more information and technologies on how they improve on their productivity. Others have also accessed financial/credit facilities for the purposes of investing to expand their dairy farms. Dairy farmers are getting organized outside the traditional co-operatives by forming dairy producer associations where they hold regional trade fairs/shows; organize trainings and workshops in collaboration with governmental and private service providers. On the other hand the informal milk traders who collect the bulk of the milk are becoming organized and seeking recognition through licensing and certification by the Kenya Dairy board. There has also been increased investment by County Governments in dairy which has increased accessibility to milk bulking and chilling/cooling facilities.

However dairy production is experiencing key challenges of low productivity among the dairy producers especially the smallholder dairy farmers who are the majority and constitute more than 70% of the total milk producers but produce about 56 – 60% of the total milk production (Odero Waitituh, 2017), seasonal milk production variation due to poor planning on fodder production and conservation and lack of good replacement stock. In a study conducted on smallholder dairy systems in the Kenya highlands focussing on the cattle population dynamics under increasing intensification, it concluded that increased intensification has influenced herd dynamics such that farmers practising semi and zero grazing systems were unable to maintain sufficient heifers to replace cows leaving the herd (Bebe, Udo, Rowland, & Thorpe, 2003). Households interviewed in the cross sectional survey of 987 smallholder dairy farms reported that 90% of dairy cows and 94% of heifers were purchased from other fellow smallholder dairy farmers and only 10% and 6% respectively were from large scale dairy farms and this justifies that there is a great demand of replacement stock by Kenyan smallholder dairy farmers who must undertake a deliberate decision of raising heifer calves. This therefore calls for a concerted effort of creating awareness of the importance of raising our own dairy replacement stock and taking into consideration the importance of calves, more focus should be placed on good calf rearing practises that will translate into high daily weight gain, faster growth, early gestation and age at first calving. These will translate into improved productivity for the Kenyan smallholder dairy farmer.

1.2 Dairy calf feeding

Dairy calves feeding and management practices directly impact on their survival and their future milk production. Recent data has shown the potential of nutrition and management during the first few months of life to influence metabolic programming and consequently the future performance of dairy cattle. Some of the studies that have followed calves through their first lactation have shown a positive relationship between early life nutrient intake and first lactation milk production (Berends, 2015) (Trouw Nutrition) . However, a range of 15-25% pre-weaning and early post-weaning mortality rates would be typical on many tropical dairy farms. In a study on dairy stock development in the tropics concluded that typical calf mortalities in the tropics of 20 to 45% are much higher than the 7 to 16% found in temperate regions because of high disease incidences and low feeding levels (De Jong, 1996). This was further compounded by the low value attached to calves reared for meat or as replacement heifers as they are deemed not to be generating any income for the farm at that particular phase. As with regard to its potential economic impact, it was calculated that a calf mortality rate of 20% can reduce dairy farm net profits by 38% compared with a target mortality level of 5%. (Moran, 2011)

In an observational study undertaken in Mukurweini district, Kenya involving 36 small holder dairy farmers who are members of Wakulima dairy farmers cooperative society that involved studying calves placed in nine observational groups and each group was having 4 calves. These groups were subjected to different feeding interventions of different quantities of milk and calf starter pellets over a period of sixty days. The results of this study showed that a combination of milk and calf starter given to the dairy calves had an overall positive effect on daily weight gains with those receiving as the feed intervention group (7) FCS+CMI (being fed on calf starter from week 2 to achieve an intake of 1 kg at weaning and being fed milk of up to 5 litres /day)was superior to the rest of the groups as it recorded the highest average daily weight gains of 0.6 kg/day while group (5) HCS+HMI(receiving 0.2 kg of calf starter and 2 litres of milk/day-a normal farmers practise)was lower to the rest and it recorded the lowest gains of 0.2kg/day (Situma, 2013). Similarly in another study undertaken in Kiambu district among 90 small holder dairy farms whose objective was to determine factors influencing calf growth and daily weight gain determined that the average daily weight gain registered was 0.21 kgs per day. The main factors attributed to it were reduced milk and concentrate intake and disease incidences and the study concluded that these low levels of calf productivity had a negative effect on the overall efficiency of the dairy production system (Gitau, McDermott, Adams, Lissemore, & Waltner-Toews, 1994).

.

Small-scale dairy farmers neighbouring major towns have a ready market for milk and prefer selling most of their milk to earn an income whereas other farmers who during the dry season when there is a shortage of milk resulting in price hikes, leads to a situation where they sell more milk at the expense of calf rearing. This results in depressed calves' growth rates, high calf mortality rates, late maturity and general economic losses in the smallholder dairy production systems. Smallholder farmers should capitalize on the rapid early growth potential of young calves which allow for greater average daily weight gains by ensuring that they pay serious attention to adequate feeding and supplementation of calves through early weaning. This will improve their performance, increase on the survival rates of dairy calves to enable them become good replacement stock as these are what will be beneficial to the small holder dairy farmer as calves are the foundation of the future dairy

herd. Innovative development of early calves weaning formulae, also known as calf milk replacers, would offer a solution in the calves' nutrition and household income in the long run. (Syomiti, Bauni, Kariuki, Wamae, Gachuiri, & Mutua, 2014).

1.3 Calf milk replacers

These are generally formulated from by-products of dairy processing together with animal or vegetable fats plus added vitamins and minerals. They provide a convenient way to feed pre-ruminant calves and can be stored long term as powder and mixed with water just prior to feeding (Trouw Nutrition). Calves can then be milk reared anywhere and fed at any time without having to source liquid whole milk. They have an impact on calf health by avoiding diseases transmitted via milk like Johnes disease and performance improvement. In a study in neighbouring Sudan to determine the effects of using milk replacer on body growth and its economic feasibility in feeding dairy calves where 38 Friesian Holstein calves were divided into two groups each fed with milk replacer and calf starter and the other with whole milk with calf starter and monitored for 90 days, It was established that those fed on milk replacer registered higher pre-weaning average daily weight gain of 0.61kgs whereas those fed on whole milk and milk starter registered 0.58 kgs (EL Jack & Ahmed, 2012). In another study determining the effects of intensified feeding of milk replacer on heifer calves on growth, puberty age, age at first calving, milk yields and economics where 80 calves were divided into two groups and subjected to two different feeding treatments of calf milk replacer from day 2 to weaning at 42nd day, one on normal diet (conventional) and the other on an intensified diet. The study concluded that those feed an intensified treatment registered higher daily weight gain of 0.68 kgs at period birth to weaning as compared to those fed a conventional diet posting a daily weight gain of 0.45 kgs .They were served earlier by 15 days and calved earlier by 14 days than those fed the conventional treatment (Davis Rincker, Vande Haar, Wolf, Liesman, Chapin, & Weber Nielsan, 2011). Kenyan smallholder dairy farmers should appreciate good calf rearing practice as an investment to reap returns from a future highly productive dairy herd.

Therefore the main question of the study reported in this thesis is;

What are the economic benefits of using calf milk replacers in small holder dairy farms in Kenya?

To answer the main question, the following sub questions will be answered,

a) What is the schedule of the adopted calf rearing programmes in small holder dairy farms using calf milk replacer?
b) What is the cost of rearing calves using calf milk replacers when compared with the traditional whole milk rearing?
c) What will be the benefits accruing from the adopted calf rearing programme of using calf milk replacer in small holder dairy farms?

d) What will be the calculated consolidated benefits of using calf milk replacer in small holder dairy farms?

The objective of undertaking this study was to evaluate the economic benefits that will emanate from using calf milk replacer when calf rearing to the Kenyan small holder dairy farmers who prefer selling more milk to earn an income to the detriment of feeding it to the calf at the required quantity. The study intended to show and determine that there is an alternative option of using a cost effective product (calf milk replacers) which Kenyan smallholder dairy farmers can also use in rearing their calves and result with good healthy calves registering good daily weight gains, enabling them become better replacement stock, ready for gestation and lactation early enough and future good productive future dairy cows.

2. Materials and methods

The study was undertaken by reviewing literature on studies previously conducted on calf rearing practises and programmes searched in the following journals; Animal science journals, Livestock Production science journals, Dairy science journals. Additional information will also be sourced from publications on life start science programme, ILRI (international livestock research institute) publications, Wageningen University Research (WUR) publications.

Information searches were based on the following key words calf nutrition, calf rearing models, performance of dairy herd replacements, effects of feeding calves on milk replacer, herd structure in smallholder dairy farms in Kenya, dairy cattle population dynamics in smallholder dairy farms in Kenyan highlands.

Information sourced was based on appropriateness of the contents, its relevance to the subject and the study theme, its reliability in relation to the source and been peer reviewed and finally its ability to help answer the sub questions and its contribution in forming objective arguments.

Excel spread sheets were used to calculate the projected feeding cost of calf rearing and long term benefits of using calf milk replacers in the context of a common herd structure in a Kenyan smallholder dairy farm.

3. Results

In selecting the calf rearing milk feeding regime we adopted what are promoted by the Kenyan department of livestock under the NAFIS (National farmers' information service) platform and the East Africa dairy development programme (EADDP) in Kenya whose lead implementers are ILRI and Heifer project international. These calf feeding regimes are what were disseminated as extension packages on calf rearing by the above two organisations and they were commonly used and adopted by dairy farmers and the EADDP is currently being implemented in key milk producing areas. (International livestock research institute(ILRI) and EADDP, 2009; Ministry of Agriculture & Livestock Dev.)

3.1 The calf rearing programme while using whole milk and calf milk replacer (CMR)

The feeding schedule illustrates the period from birth to weaning and quantities of feed which include whole milk, calf milk replacer, calf starter and hay/straw period fed to calves from birth to weaning.

Table1. The calf rearing feeding schedule - source: (International livestock research institute(ILRI) and EADDP, 2009; Trouw Nutrition)

period	**whole milk**						**Calf milk replacer(CMR)**					
				calf starter(CS)								
period	amount	amount p	amount/w	amount/d	amount/week		amount	amount/d	amount/week			
Day 1	colostrum	4+2	6				colostrum	4+2	6			
Day 2-3	3lts*2	6	12				3lts*2	6	12			
Day 4-7	2 lts * 2	4	16				2lts* 3	6	24			
2nd week	2.5lts*2	5	35	0.5	3.5	hay	3lts* 2	6	42	CS	chopped straw	
3rd week	2.5lts*2	5	35	0.5	3.5	hay	3.5lts* 2	7	49	CS	chopped straw	
4th week	2.5lts*2	5	35	0.75	5.25	hay	3.5lts* 2	7	49	CS	chopped straw	
5th week	2.5lts*2	5	35	0.75	5.25	hay	3.5lts* 2	7	49	CS	chopped straw	
6th week	2.5lts*2	5	35	0.75	5.25	hay	3lts* 2	6	42	CS	chopped straw	
7th week	2.5lts*2	5	35	0.75	5.25	hay	2lts *2	4	28	CS	chopped straw	
8th week	2.5lts*2	5	35	0.75	5.25	hay	2lts *2	4	28	CS	chopped straw	
9th week	2.5lts*2	5	35	1	7	hay	2lts *1	2	14	CS	chopped straw	
10th week	2lts* 2	4	28	1	7	hay						
11th week	2lts* 2	4	28	1	7	hay						
12th week	1.5lts*2	3	21	1.5	10.5	hay						
13th week	1.5lts*2	3	21	1.5	10.5	hay						
14th week	1 lts*2	2	14	1	7	hay						
total(litres)			**408**						**325**			
total(kgs)					**82.25**				**48.75**	50		

3.2 Calculating the feeding cost of rearing calves from birth to weaning period of both rearing programmes

The following table illustrates calculations where I was determining and comparing the feeding cost of rearing calves using both whole milk and calf milk replacer. The figures used **(computed in table 1 above)** were derived from the total amounts of whole milk consumed 408 litres, total amount of calf milk replacer powder needed to reconstitute the total

amount of calf milk replacer consumed 325 litres = 48.75 kgs, the total amount of calf starter consumed 82.25 kgs for whole milk feeding schedule and 50kgs for the milk replacer feeding schedule and the labour in man hours in both feeding schedules respectively required to feed the calves during the birth to weaning duration. To quantify the figures in monetary terms, we based our calculations with the prevailing current producer price of milk paid to dairy farmers by the two leading dairy processors at Kenya shillings (Kshs) 35 per litre, the retail price of calf starter and calf milk replacer (Sprayfo brand) at the local agro farm input store as at 1st of June 2018. Labour prices were pegged at the normal local rates paid by farmers when hiring farm labourers working for 56 hours per week (in June 2018) i.e. KSh 41.7 per hour

Table2. The feeding cost of rearing calves using both whole milk & calf milk replacer.

	whole milk program				**CMR program**		
item	amount	cost	total cost		amount	cost	total cost
		(Kshs)	(Kshs)			(Kshs)	(Kshs)
milk(Litres/Kilos)	408	35	14280		49	235.2	11524.8
calf starter(Kilos)	82.25	41.6	3421.6		50	41.6	2080
labour(Manhours	98	41.7	4086.6		63	41.7	2627.1
Total costs(Kshs)			**21788.2**				**16231.9**
Total costs(Euros)			189.5				141.1
(1 € = Kshs 115)							

3.3 Determining what are the benefits of rearing calves using calf milk replacer as compared to whole milk

In this section, Table 3 illustrates the cost of rearing calves by comparing using whole milk and calf milk replacer on dry matter basis while also calculating the crucial nutrients of both products i.e fat and protein content fed to the calf per day and how much it costs the dairy farmer to feed either whole milk or calf milk replacer per day. The figures used in computing are derived from the current market milk and of calf milk replacer prices as at 1st June, 2018. For whole milk composition, the Kenya standard/East African standard No. KS.EAS 67:2007 for raw whole milk composition was used whereas for the calf milk replacer is what was indicated in sprayfo bag tab.

Table 3. Comparing the content and cost of whole milk and calf milk replacer

Comparing cost of whole milk & calf milk replacer (CMR)						
	whole milk			CMR		
milk price(Kshs)	35		price of CMR/kg	235.20		
total solids content milk(%)	12.5%		DM% content of CMF	96.5%	from milk replacer bag tag	
Protein content	3.2%		protein content of CI	22.0%	from milk replacer bag tag	
fat content	3.7%		Fat content of CMR	19.0%	from milk replacer bag tag	
weight fed to calves/day(lts)	4.2			5.2		
Output						
Crude protein(% DM)	25.6%			22.8%		
Fat (% DM)	29.6%			19.7%		
Cost of kg /DM(Kshs)	280			243.7		
DM fed per calf/day(kgs)	0.52			0.77		
CP fed per calf/day(kgs)	0.13			0.18		
Fat fed per calf/day(kgs)	0.15			0.15		
cost per calf/day(Kshs)	**145.7**			**188.6**		
cost per calf/day(Euros)	**1.27**			**1.64**		

3.4 Consolidated benefits

They were expected to be both short term like the better average daily weight gain, faster growth and long term from earlier age at first calving ,changes on the herd structure and resultant yields in milk production as tabulated below in the herd size growth projection. To calculate the herd size projection I used the Cornell University cooperative extension internal herd growth calculator which utilises the herd statistics given in projecting the increases in subsequent years herd structure and compared the current (old situation) and the new situation after intervention.

The figures used in the current herd size in smallholder dairy farms in Kenya are derived from a study undertaken on cattle population dynamics under increasing intensification (Bebe, Udo, Rowland, & Thorpe, 2003) and similar studies on herd dynamics on small holder dairy farms in Kenyan highlands by B O Bebe which put the herd size and structure in small holder dairy farms as indicated. The figures used for average production per lactation for Kenyan smallholder dairy farmers were from studies undertaken on lifetime productivity of dairy cows in smallholder farming systems in the central Kenyan highlands and assessment of performance of smallholder dairy farms in Kenya respectively (Rufino, Herrero, Van Wijk, & Hemerik, 2009; Lanyasunya, Wang, Mukirisia, & Abdulrazak, 2006; Kimenchu, Mwangi, Wambugu, & Gitunu, 2014)

Table 4(a). Herd structure - old situation

Initial Herd Size	
Cows - Milking and Dry	2
Heifers - 12+ Months	1
Heifers - 0-12 Months	1
Herd Statistics	
Cull Rate (%)	25%
Calving Interval (Months)	16.0
Age at First Calving (Months)	30.0
Calf Births Dead on Arival (%)	0%
Heifer Cull & Death Rate (% / year)	10%
Percent Heifer Calves in Cows	40%
Percent Heifer Calves in 1st Calf Heifers	40%
milk yields /lactation 2500-4500litres/cow	3500.00

Table 4(b). Herd growth projection in the old situation

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Cows	2.0	2.0	2.2	2.1	2.0	1.9	1.9	1.8	1.7	1.7	1.6
Heifers - 12+ Months	1.0	1.4	0.9	1.0	0.9	0.9	0.8	0.8	0.8	0.7	0.7
Heifers - 0-12 Months	1.0	0.6	0.7	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5
Milk yields/lactation (litres)	7,000.00	7,000.0	7,735.00	7,210.76	7,072.40	6,772.48	6,548.04	6,305.18	6,081.69	5,861.92	5,651.79
Gross income from milk (Kshs)	245,000.0	245,000	270,725.0	252,376.5	247,534.0	237,036.9	229,181.4	220,681.2	212,859.0	205,167.2	197,812.6

New situation

In this new situation after the intervention of feeding calves with milk replacers which resulted in enhanced growth and earlier age at first calving, hypothetically put at 28 months and a reduced calving interval of 435 days (14.5 months) has resulted in marked improvement in the herd size and this will in turn result in increased milk yields as illustrated in the following table 5(a)&(b).

Table 5(a) Herd structure in new situation

Initial Herd Size	
Cows - Milking and Dry	2
Heifers - 12+ Months	1
Heifers - 0-12 Months	1
Herd Statistics	
Cull Rate (%)	25%
Calving Interval (Months)	14.5
Age at First Calving (Months)	28.0
Calf Births Dead on Arival (%)	0%
Heifer Cull & Death Rate (% / year)	10%
Percent Heifer Calves in Cows	40%
Percent Heifer Calves in 1st Calf Heifers	40%
milk yields /lactation 2500-4500litres/cow	3500.00

Table 5(b) Herd size growth projection in new situation

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Cows	2.0	2.2	2.4	2.5	2.5	2.6	2.7	2.7	2.8	2.9	3.0
Heifers - 12+ Months	1.0	1.2	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.2	1.2
Heifers - 0-12 Months	1.0	0.8	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0
Milk yields/lactation (litres)	7,000.00	7,612.5	8,544.38	8,581.46	8,885.53	9,086.56	9,334.30	9,572.50	9,822.99	10,077.66	10,339.84
Gross income from milk (Kshs	245,000.00	266,437.5	299,053.13	300,350.94	310,993.60	318,029.61	326,700.47	335,037.39	343,804.65	352,717.98	361,894.28

Using the excel spread sheets it was possible to calculate the projected herd growth in size, the resultant increases in milk yields and the gross income emanating from the dairy herd. After comparing between the old and the new situation, it is evident that the intervention of using calf milk replacer when rearing calves result in numerous benefits cumulatively resulting in herd size growth and improved milk yields. In quantifying the benefits in terms of gross income from milk sales, a small scale dairy farmer will be able to generate more income if he adopts the intervention in the new situation where for example when age at first calving was reduced from 30 months to 28 months.

4. Discussion of results

The objective of undertaking this study was to evaluate the economic benefits that will emanate from using calf milk replacer when calf rearing to the Kenyan small holder dairy farmers who prefer selling more milk to earn an income to the detriment of feeding it to the calf at the required quantity. It also determined that there was an alternative option of using a cost effective product (calf milk replacers) with equally good results which smallholder dairy farmers can also use in rearing their calves.

For the whole milk and calf milk replacer feeding regimes, the two schedules allocated milk amounts was at 10 - 15% of the calf's body weight. The two feeding schedules also illustrate the increase of milk volumes on week 2 onwards to week 5 for milk replacer and week 9 for whole milk before reducing milk volumes towards weaning to encourage and stimulate more solid feed intake (calf starter and hay/straw) which will stimulate ruminal development. The gradual step down process was encouraged to minimize stress of transiting from liquid (milk) to solid (roughage) feed and also to prevent sharp weight gain drop during the weaning phase. This concurred with literature from a study on effects of calf nutrition on dairy herd replacement (Morrison, et al., 2011)which determined that if you feed more milk or milk replacer it inhibits the intake of calf starter which is crucial for calf rumen development especially the development of calf rumen papillae which are essential in preparing the calf for the ruminant diet. In addition it was crucial to maintain the dry

matter content of the calf milk replacer (CMR) at 15% in order to match the protein and fat content that meet the needs of a calf on a dry matter basis. (EL Jack & Ahmed, 2012; Trouw Nutrition)

Lifetime performance of dairy cows is influenced by early life development and dairy farmers have the ability to manipulate this early life programming through nutrition. This manipulation must start immediately after birth and continue for at least 5 weeks which must be inform of liquid feed to have a positive influence on lifetime performance (Soberon, Raffrenato, & Everett, 2012). The objective of the Kenyan smallholder dairy farmer has to be to achieve during calf rearing strong growth, less disease incidences and optimal ruminal development which will culminate to achieving a dairy cow having early first calving age, higher milk yields in the first lactation, strong durable cows and a higher lifetime production but the low level of calf productivity in Kenyan small holder dairy farms has negatively impacted on the overall efficiency of the Kenyan smallholder dairy production system. An intervention of good calf rearing management with target key performance indicators has to be adopted to realise good replacement stock. Previous Kenyan dairy project (NDDP) had implemented good calf rearing programmes and registered reduced calf mortality rates from 20% to 8% by introducing individual calf pen housing and bucket milk feeding (De Jong, 1996).This study determined that Kenyan smallholder dairy farmers can rear calves using milk replacers at a lesser total cost of € 141.1 than when using whole milk at € 189.5 during the birth to weaning period although the daily feeding costs per calf when using milk replacer are high at € 1.64 per day as opposed to € 1.27 per day when using whole milk. However, what is of critical importance is the amount of dry matter (DM) fed per day and if it meets the calf body requirements. In our study, when fed on milk replacers calves were fed 0.77 kgs of DM/day whereas those on whole milk were fed 0.52kgs of DM/day. This is due to the fact that when reconstituting our milk replacer we maintain the ratio of 150 gms of CMR: 1 litre of water = 15% DM. On the other hand when evaluating the energy and protein contents of both whole milk and CMR fed, the study found that both milk and CMR were providing the same amount of fat of 0.15kg/day (150gms) whereas for protein CMR was providing more protein at 0.18kgs/day (180gms) as opposed to whole milk which was providing 0.13kgs/day (130gms). Did our calf milk replacer feeding meet the calf's daily requirements? Yes as according to NRC2001, a calf born at 30 kgs live weight with a target to grow at 400 grammes for the first three weeks requires to have a dry matter intake of 0.47kgs of DM/day,124 grammes of crude protein and 2.22 Mcal of energy /day and all these were achieved.

Dairy cattle population in smallholder dairy systems in the Kenyan highlands is changing due to increasing intensification. These has influenced dairy herd dynamics such that dairy farmers practising semi and zero grazing systems were unable to maintain sufficient heifers to replace cows leaving the herd through involuntary & voluntary means and had to acquire replacements externally (Bebe, Udo, Rowland, & Thorpe, 2003). In this study where we compared the two scenarios of the old situation without improvement against the new

situation adopting good calf feeding using CMR in relation to projecting herd size growth, it is evident that the intervention of using calf milk replacer when rearing calves result in numerous benefits cumulatively resulting in herd size growth and improved milk yields. In quantifying the benefits in terms of gross income from milk sales, a smallholder dairy farmer will be able to generate more income if he adopts the intervention as illustrated in the new situation (table 5b)where for example when age at first calving was reduced from 30 months to 28 months, the herd size improves progressively in following years. If also the age at first calving is reduced further to 26 months, the herd size grows more progressively in the subsequent years as opposed to the old situation (table 4a) where the herd size in the long term reduces due to the longer age at first calving and the long calving interval. This therefore justifies the importance of improving on calf rearing especially on feeding in the pre-weaning periods.

Our study in its methodology could not ascertain the actual daily weight gain for calves fed on calf milk replacer within the Kenyan smallholder dairy farming context as no studies have been undertaken but only on calf rearing using whole milk but for milk replacers could only infer from similar studies done elsewhere and use it as a reference. In addition, some breeds in Kenyan smallholder dairy farms are breed crosses with different phenotypic characteristics unlike the pure/pedigree Friesian Holstein used in the various experiments and this might register slightly different results in terms of weight at birth and daily weight gain. In future, a study to determine the effect of calf milk replacers on growth of dairy calves crosses to get actual daily weight gains may be considered. The rearing post weaning period must sustain the pre weaning period growth gains by transiting to feeding adequate good quality roughage and supplementing with good quality concentrates for the smallholder dairy farmer to realise a good replacement cow.

5. Conclusion and recommendations.

The objective of this study was to evaluate what would be the economic benefits of using calf milk replacers against using whole milk for the Kenyan smallholder dairy farmer. From the methods and results obtained it concluded that it was possible to rear dairy calves using calf milk replacers rather than whole milk for the Kenyan dairy farmers by following the illustrated feeding schedule in table 1.

The study also concluded that it is significantly cheaper for the Kenyan smallholder dairy farmer to rear calves using calf milk replacer than when using whole milk although whole milk is nutritionally superior. It also concluded that when he rears calves using milk replacer more economic benefits will accrue in terms of improved faster growth, early age at first calving and improved dairy herd size growth with resultant improvement in gross income from milk sales. In quantifying the benefits in terms of gross income from milk sales, a small

scale dairy farmer will be able to generate more income if he adopts the intervention than when he does not and continues with the old situation of feeding inadequate whole milk

The economic benefits of rearing calves using calf milk replacers can only be realised if the producer price of whole milk is higher than that of equivalent amount of calf milk replacer. Kenyan small holder dairy farmers must adhere to the feeding schedule as illustrated in table 1.or as defined by the manufacturer. They should ensure they reconstitute the calf milk replacer using the appropriate ratios as defined by the manufacturer and they source their calf milk replacer from reputable sources while also ensuring that the calf milk replacer proteins are from milk sources but not from vegetable sources to minimize gastrointestinal disorders.

Bibliography

Bebe, B., Udo, H., Rowland, G., & Thorpe, W. (2003). Smallholder dairy systems in the Kenyan Highlands: Cattle population dynamics under increasing Intensification. *Livestock Production Science, 82*, 211-221.

Berends, H. (2015, April 23). Calf nutrition to optimise lifetime performance of dairy cows. *Society of feed technologists*, p. 9.

Davis Rincker, L., Vande Haar, M., Wolf, C., Liesman, J., Chapin, L., & Weber Nielsan, M. (2011, July). Effects of intensified feeding of heifer calves on growth,puberty age,calving age,milk yield and econmics. *Journal of Dairy science, 94*(7), 3554 - 3567.

De Jong, R. (1996). *Dairy stock development and milk production with smallholders.* Wageningen Agricultural University. Wageningen: WUR.

East African Dairy Development Programme. (2017). *East African Dairy.* Nairobi: EADD.

EL Jack, R., & Ahmed, K. (2012, April). The effects of using milk replacer on body growth and its economic feasibility in feeding dairy calves. *Agricultural Research Journal, 2*, 183 - 188.

Ettema, F. (2016). *Dairy development in Kenya.* PUM & SNV.

Gitau, G., McDermott, J., Adams, J., Lissemore, K., & Waltner-Toews, D. (1994). Factors influencing calf growth and daily weight gain in smallholder dairy farms in Kiambu district,Kenya. *Preventive Veterinary medicine, 21*(2), 179 -190.

International livestock research institute(ILRI) and EADDP. (2009). *Calf rearing - EADD leaflet 3*. Retrieved May 24, 2018, from CGspace: https://cgspace.cgiar.org

KAGRC. (2017). *Bulls information*. Retrieved 04 26, 2018, from Kenya animal genetics resource centre for superior animal genetics: www.kagrc.co.ke

Kenya dairy board. (2012-2020). *Kenyan national dairy sector master plan*. Retrieved 12 22, 2017, from https://kdb.co.ke/press/publications/reports/5-kenya-national-dairy-master-plan/file

Kenya Markets Trust. (2017, December). *Dairy sector at a glance*. Retrieved December 30, 2017, from Kenya markets trust: www.kenyamarkets.org

Kenya National Bureau of Statistics. (2017). *Country population key facts*. Retrieved April 26, 2018, from country statistical releases: www.knbs.or.ke

Kimenchu, D., Mwangi, M., Wambugu, S., & Gitunu, A. (2014). Profitability assessment of smallholder dairy farms in central Kenya. *International journal of innovative research and development, 3*(9), 7891– 7899.

KLBO. (2017). *home page*. Retrieved May 03, 2018, from Kenya livestock breeders organisation: www.klbo.co.ke

Lanyasunya, T. P., Wang, H., Mukirisia, E., & Abdulrazak, S. (2006). Performance of dairy cows in different livestock production systems on smallholder farms in Bahati Division, Nakuru District, Kenya. *Pakistan Journal of Nutrition, 5*(2), 130-136.

Ministry of Agriculture & Livestock Dev. . (n.d.). *Calf rearing* . Retrieved May 12, 2018, from NAFIS(National farmers information service): www.nafis.go.ke/livestock/dairy-cattle-management/calf-rearing

Moran, J. B. (2011). Factors affecting high mortality rates of dairy replacement calves and heifers. *Asian-Aust. J. Anim. Sci., 24*(9), 1318-1328.

Morrison, S., Wicks, C., Carson, A., Fallon, R., Twigge, J., Kilpatrick, D., et al. (2011, November 23). Effects of calf nutrtion on the performance of dairy herd replacement. *Animal science, 6*(6), 909 - 919.

Odero Waitituh, J. (2017, july). Smallholder dairy production in Kenya. A review. *Livestock research for rural development newsletter*.

Onono, J., & Wieland, B. (July 2012). Productivity in different cattle production systems in Kenya. *Tropical animal health and production, 41*(3).

Rademake, C. J., Bebe, B. O., Lee, J., & Kilelu, C. (2016). *Sustainable growth of Kenya's dairy sector.* Wageningen: Wageningen University & Research.

Rufino, M., Herrero, M., Van Wijk, M., & Hemerik, L. (2009). Lifetime productivity of dairy cows in small holder farms in central highlands kenya. *Animal consortium, 3*(7), 1044-1056.

Situma. (2013). *The impact of enhanced nutritional and feeding practises on growth and health of dairy calves in Mukurweini.* Nairobi University, Nairobi.

Soberon, F., Raffrenato, E., & Everett, R. (2012, february). Preweaning milk replacer intake and effects on long term productivity of dairy calves. *Journal of Dairy science, 95*(2), 783 - 793.

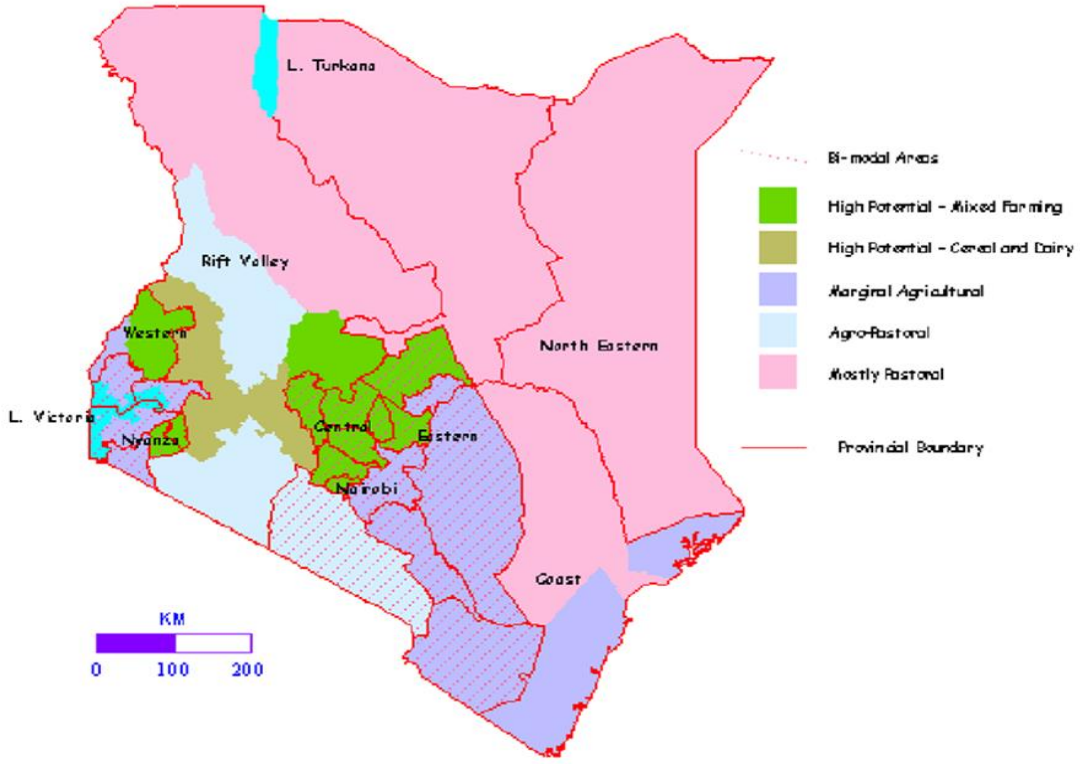
Syomiti, M., Bauni, M., Kariuki, I., Wamae, D., Gachuiri, C., & Mutua, S. (2014). Evaluation of early calves weaning diet as milk replacer for smallholder dairy production systems in Kenya. *African crop science journal, 22*(4), pp. 951 - 957.

Tegemeo institute of Policy Analysis and Research. (2011). *Productivity trends and performance of dairy farming in kenya.* Nairobi: Tegemeo institute of Policy Analysis and Research.

Trouw Nutrition . (n.d.). *Life start*. Retrieved april 30, 2018, from Life start sciences: www.lifestartscience.com

Appendices

Figure 1: Kenya's Production/Livelihood Systems



Permission:

I: Benjamin K Mungai

□ grant permission for the inclusion of my graduation paper in the repository for archive or accreditation purposes.

Date: 14/06/2018

Study programme: International Dairy Management

Graduation field of study: BSc in Animal Husbandry