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EVALUATION OF EARLY CALVES' WEANING DIET AS MILK REPLACER FOR SMALLHOLDER DAIRY PRODUCTION SYSTEMS IN KENYA

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ABSTRACT

Small-scale dairy farmers in Kenya are interested more in selling milk to earn income, especially during dry seasons when milk prices hike. This results in depressed calves' growth rates, high calf mortality rates, late maturity and general economic losses in the smallholder dairy production systems. Innovative development of early calves weaning formulae, as milk replacers, would offer a solution in the calves' nutrition and household income in the long run. A study was conducted to determine the effectiveness and economic returns to replacing milk with formulated early calf weaning diets (EWDs) on the survival and general performance of dairy calves in Kenya. Treatments included milk feeding up to 105 days (Control) and with milk (28 days) + EWD, fortified or not fortified with effective microorganisms (EM), diamond-V or Diatomite (DT), up to 105 days. There was no ($P>0.05$) differences in average daily weight gain of the calves as a result of the treatments. However, the EM-treatment had significantly ($P<0.01$) higher calve dry matter (DM) intake (g kg^{-1} day) than in the other treatment groups. Due to feeding with EWD, total milk saved for the farmer was 9 $kg^{-1}cow^{-1}day^{-1}$; equal to 945 kg for the 105 period, valued at US$614. For the conventional milk feeding (control), total milk saved was 5 kg^{-1} cow^{-1} day^{-1}; equal to 525 for the 105 period, valued at US$ 341. Significant incidences of diarrhea were observed in the control (milk) and the Diamond-V fortified treatments. Signs of hair loss and discolorations were observed in DT-fortified EWDs. EM- fortification reduced disease incidences, thus, EWD fortified with this microbial feed additive can be an effective milk- replacer in smallholder dairy production systems to wean dairy calves at 28-35 days with good economic and performance results.

Key Words: Diarrhea, dairy calves, hair loss, Diatomite

RÉSUMÉ

Les petits fermiers agricoles au Kenya s'intéressent plus à la vente du lait pour générer des revenues, spécialement durant les saisons sèches lorsque le prix du lait est élevé. Ceci résulte en une inhibition du taux de croissance des veaux, des taux de mortalités élevés, retard de maturité et pertes économiques dans les systèmes de production laitier des petits fermiers agricoles. Le développement des formules innovées de sevrage précoce des veaux en remplacement au lait pourrait offrir une solution dans la nutrition des veaux et à la longue améliorer le revenu des ménages. Une étude était faite pour déterminer l'efficacité et le bénéfice du remplacement du lait par une alimentation formulée de sevrage précoce des veaux (EWDs) pour la survie et la performance des veaux au Kenya. Les traitements comportaient l'alimentation par le lait jusqu'à 105 jours (témoin) et le lait (28 jours) + EWD, fortifié ou non par des microorganismes efficaces (EM) , le diamant-V ou le Diatomite (DT), jusqu' à 105 jours. Il n'y avait pas de différences significatives ($P>0.05$) des traitements sur la moyenne du gain quotidien de poids des veaux. Par ailleurs, le traitement de fortification avec EM avait significativement ($P<0.01$) induit une ingestion de la matière sèche la plus élevée (DM) (g kg^{-1} day) par rapport autres traitements. Par l'alimentation à l'EWD, les fermiers ont pu gagner 9 kg $vache^{-1}jour^{-1}$ équivalant à 945 kg pour toute la période de 105 jours et évalués à US$614. Pour l'alimentation conventionnelle en lait (témoin), le total épargné était de 5 kg par vache jour-1

équivalent à 525 kg d'une valeur d'US $ 341. Des incidences de diarrhée étaient observées dans le control (lait) et le traitement EWD fortifié avec Diamond-V tandis que les signes de perte et décoloration des poils étaient observés dans l'EWD fortifié de DT. La fortification avec les microorganismes EM a réduit les incidences de maladies. Dès lors EWD fortifié avec les microorganismes EM peut constituer un remplacement efficace du lait dans les systèmes de production laitières pour sevrer les veaux de 28-35 jours avec des résultats économiques et des performances satisfaisants.

Mots Clés: Diarrhée, veaux, perte de poils, Diatomite

INTRODUCTION

In an attempt to maximise milk sales to cope with the rising immediate costs of living, bull calves on smallholder farms in Kenya, suffer neglect and in most cases die of malnutrition. For this reason, farmers incur high rates of calf mortality of between 15-20% compared with approximately 5% or less in well managed farms and low calf growth rates (growth rates of less 300 g per day compared with more than 500 g per day (Odongo and Njuho, 1990). Small-scale dairy farmers in Kenya are more interested in milk sale to earn more income, especially during dry seasons when milk prices are high (Land O' Lakes, 2003). This results in depressed calves' growth rates, high calf mortality rates, late maturity and general economic losses in the smallholder dairy production systems.

Innovative development of early calves weaning formulae as milk replacers would offer a solution to poor calves' nutrition and household income in the long run. A cost effective milk replacer feeding systems can increase both the welfare of dairy calves and dairy profitability (Kehoe *et al.*, 2006). Such feeding technologies include utilisation of locally available feed resources as ingredients in early calves' weaning diets. According to Khan and Azim (2000) and Khan *et al.* (2002), early weaning reduces the amount of milk consumed by the calves. This, not only releases more milk for human consumption, but also increases cash income for the farmer through increased milk sales, and also reduces the cost of rearing the calves during their nursing period.

Feed fortification with feed additives such as probiotics and yeast cultures have been reported to manipulate the rumen environment for efficient utilisation of fibrous feeds, especially in neonate ruminants which possess little cell-wall and starch degrading enzyme activity (Anjum *et al.,* 2006). Effective microorganisms (EM) and Diamond-V, which are available in Kenya, are such microbial feed additives, which can influence early establishment of fibrolytic, amylolytic and proteolytic capacities influential for the early expansion of the reticulo-rumen epithelia in calves (Hagg *et al.*, 2012). Such an early development in reticulo-rumen fermentation will enable a timely hepatic adaptation to volatile fatty acids assimilation (Silva *et al.,* 1986). Therefore, this early nutrient release in the reticulo-rumen can facilitate early weaning, reduce labour costs, save milk and lessen health issues associated with late weaning. On the other hand, mineral clays such as diatomite, which is negatively (-ve) charged, is capable of trapping ammonia, a positively (+ve) charged gas, therefore, enhancing efficient utilisation of ammonia-N. The objective of this study was to evaluate the performance and economic efficacy of an early calves weaning formula as a milk replacer for small-holder dairy production systems.

METHODS AND MATERIALS

Study area. The study was conducted on-station at the Kenya Agricultural Research Institute (KARI) Muguga South Research Station in Kenya from October 2012 to January 2013. KARI Muguga South is located approximately 26 Km from Nairobi, along the Nairobi-Naivasha highway.

Test diet formulation. The chemical composition of the experimental diet is presented in Table 1. Feedsoft, a computer software package was used in formulation of the test diet. Mixing of the ingredients and pelleting (Table 2) was done at Unga farm Care Ltd., Nairobi, Kenya.

TABLE 1. Formula composition of test milk replacer diet

Parameter/unit	Value
Energy (Mj kg^{-1})	11
Crude protein (%)	23
Crude fibre (%)	9.10
Calcium (%)	0.90
Total phosphorus (%)	1.50
Crude fat (%)	3.05

TABLE 2. Inclusion rates of ingredients in the test diet (%)

Ingredients	Kilogrammes
Maize	14
Maize germ and bran meal	30.0
Pollard	20
Soya bean	15.8
Omena	3
Cotton seed cake	13.6
Extracted sunflower seed meal	2
Stockfeed lime	1
Salt	0.4
Vitamin and mineral premix	0.2
	100

A**nimals, diets and experimental design.** Twenty friesian (*Bos taurus*) bull calves with average age of 7-10 days and body weight 37.01±3.52 kg were divided into five groups of four animals in each group, based on their body weight. The 7-10 day old calves were obtained both from KARI Muguga South Research Station and farmers fields in Limuru and Githunguri districts of Kiambu County in Kenya. At one week post-colostrum, calves were assigned to one of the 5 treatments in a randomised block design. The treatments were: (i) milk feeding (up to 105 days (control), (ii) milk feeding (28 days) + Early Weaner Diet (EWD) (77 days), (iii) milk feeding 28 days + EWD (77 days) + Effective microorganisms (EM), (iv) milk feeding 28 days + EWD (77 days) + Diamond-V (DV), and (v) milk feeding 28 days + EWD (77 days) + Diatomite (DT). Where fortification was a treatment, early weaner diet was fortified with either effective microorganisms (EM) at the rate of 1 ml l^{-1} EM, Diatomite, 4 g, or Diamond-V, one teaspoonful. All feed additives were administered in the mornings' milk feeding at 7-28-day old, and in drinking water from 29 to 105 days.

All calves received water and basal diets *ad libitum.* The basal diet consisted of 50% good quality Napier grass (harvested at the recommended 6-8 weeks of maturity stage), Rhodes grass hay (20%) and *Leucaena leucocephala* (20%). Basal diet and EWDs were fed separately to individual calves twice daily at 0830 and 1530 hours.

The Control group which represented a standard well managed farm, received milk twice a day at the rate of 6 kg per calf per day; while the EWD test group received either fortified or non-fortified diets at 1-4 kg per day, as the animals grew. Calves were introduced to the test diets during the 2nd week of age for acclimatisation to the new feed before milk withdrawal.

Animal housing and management. The calves were housed in individual roofed pens measuring 3 m x 4 m, with open side walls. Three sides of the pens were covered with a long polythene sheet to minimise extreme weather conditions such as cold and rain during the experimental period. The animals were ear-tagged for identification and de-wormed once a month using Nilzan Plus at a rate of 25 to 50 ml per animal, depending on the live weight at the time. The active ingredient of this de-wormer (Nilzan) is 1.5% w/v levamisole hydrochloride B. P, 3.0% w/v Oxyclozanide B. P and 0.38% w/v Colbalt Sulphate.

Data collection. The parameters evaluated included general animal health observations, growth rates, basal feed intake and economic data (gross margins). In determination of growth rates, live weight was taken at the beginning of the study and then on weekly basis throughout the experimental period. Calves were denied access to feed and water overnight prior to weight measurement. Data collection on feed intake started at 21st day, preceded by 14 days acclimatisation period. Milk withdrawal started at 28th day and gradually up to 35th day of age. Feed provided to and refused by the calves was recorded daily, and 0.5 kg samples of the fresh and refusals were collected and oven-dried at 60 °C.

Data on economic performance were captured from the gross margins calculated from the differences of the cost of inputs and that of outputs and prevailing procurement price in least-cost feed formulations of the test diets and that of milk.

Statistical analysis. Data were subjected to analysis of variance (ANOVA) using GenStat version 14th edition. Significant differences were detected at P<0.05. Significant differences among treatment means were separated using Least Significant Difference (LSD). Economic data were determined from gross margins calculations (costs of output minus input costs).

RESULTS

General animal health observations. While incidences of diarrhea were observed in the control (milk) and Diamong-V fortified treatments, there were no cases of disease symptoms in the EM-fortified EWDs. Signs of hair loss and discolorations were observed in calves fed DT-fortified EWDs.

Animal performance. Data on the growth rates of the experimental animals and dry matter (DM) intake of the basal diet are presented in Table 3. There were no significant (P>0.05) difference in daily weight gains of the calves due to treatments. However, significant (P<0.01) differences in DM intake of the basal diet across treatments were recorded. The highest DM intake was registered in the EM fortified EWDs; while the other treatments had similar DM intake values as the control.

TABLE 3. Growth rates (g kg^{-1} day) of the experimental animals and dry matter (DM) intake of the basal diet (kg day^{-1})

Treatment	Growth rates (kg day^{-1})	DM intake (kg day^{-1})
Milk (control)	0.87	1.04
EWD +0	0.86	1.11
EWD + EM	0.84	1.30
EWD +DV	0.85	1.06
EWD + DT	0.90	1.13
P-value	NS	**
S.e.d	0.086	0.074

**P<0.01
EWD = Early weaner diet, EM = Effective microorganisms, DV = Diamond-V, DT = Diatomite, DM = Dry matter, LSD = Least significant differences of means, TR = Treatments, NS = Not significant

Economic performance. The average total cost of rearing one dairy calf on the formulated test diet as a milk substitute from day 28-35 up to 105 days was US$173, while the total cost of calf rearing using the conventional methods of milk feeding up to the same age was US$407 (Table 4). The highest gross margins were registered with EM-fortified EWD, while the lowest (negative gross margin) was in the control treatment (milk). Farmers can save approximately 9 kgs of milk per cow per day when EWD is used for calf rearing, as compared to only 5 kgs of milk are saved per cow per day for the control.

As a result of feeding EWD, the total milk saved during the 105 day-calf rearing period is 9 kg cow^{-1} day^{-1} multiply by105 days = 945 kg (milk savings). At US$ 0.65 per kg of milk, the total savings would be valued at 945 kg milk multiply by 0.65 = US$614. For conventional milk feeding, the total milk saved is 5 kg cow^{-1} day^{-1} (Table 4). For a 105-day calf rearing period, the total milk saved in the control group would be 5 kg cow^{-1} day^{-1} multiply by 105 days=US$525. This is equivalent to 525 kg milk multiply by US$ 0.65 = US$ 341.

DISCUSSION

General animal health observations. There were no cases of disease incidences in calves on the EM-fortified EWDs. EM is said to have beneficial microorganisms which suppress the harmful ones such as salmonella (Cremonini *et al.,* 2002). The high incidences of diarrhea observed in Diamond-V treatments was possibly due to a rapid intake of the early weaner diets. Diamond-V consists of yeast cultures and their metabolites, with a sweet aroma which may have served as an appetiser in this treatment group, thus the rapid feed intake.

According to Kehoe *et al.* (2006), the nature of neonatal calves' diet plays a role in frequency

TABLE 4. Gross margin (US$) accruing from milk replacer diets of early weaned bull calves in Kenya

T1 (Control)	Inputs (A)	Rate of inputs (kg) (milk consumed by calves (B)	Unit cost of input (C) US$	Total cost of input (D) BxC	Outputs (milk produced/ cow (10*105d) minus milk consumed by calves (milk saved) (E)	Unit cost of output (F)	Value of output (G) ExF	Gross margin (H) G-D
	Milk	520	0.65	336.5	530	0.65	344.5	-63.2
	Drugs	3	23.5	70.6				
				407.1				
T2	Milk	64	0.65	41.4	986	0.65	640.9	453.72
	EWD	180	0.4	75.2				
	Drugs	3	23.5	70.6				
				187.2				
T3	Milk	64	0.65	41.4	986	0.65	640.9	520.2
	EWD	180	0.4	75.2				
	E M	1	4.1	4.1				
				120.7				
T4	Milk	64	0.65	41.4	986	0.65	640.9	447.9
	EWD	180	0.4	75.2				
	DV	2	2.9	5.9				
	Drugs	3	23.5	70.6				
				193.1				
T5	Milk	64	0.65	41.4	986	0.65	640.9	452.0
	EWD	180	0.4	75.2				
	DT	1	1.8	1.8				
	Drugs	3	23.5	70.6				
				189.0				

Assumptions: Average milk production in the first three and half months of lactation is 10 kg cow^{-1} day^{-1}. Total EWD intake in the whole feeding trial period is 180 kgs. Experimental animals fell sick at least 3 times during the trial period. 1 US$= Kes 85. Other factors held constant

of occurrence of calf scours. Early calves' weaning with dry feeds has been reported to reduce calf scours, compared to milk (liquid) feeding. Signs of hair loss and discolorations observed in DT-fortified EWDs, were possibly associated with copper deficiency due to mineral interactions. EM utilisation as a feed additive in the neonatal diets has been reported to reduce incidences of disease occurrence such as diarrhea (Anjum *et al.,* 2006). Our findings are in agreement with those of D'Souza *et al.* (2002), Fuller (1987) and Cremonini *et al. (* 2002), who reported cases of reduced disease incidences in both humans and animals when a commercial probiotic product was used.

Animal performance. Feeding of a formulated early weaner diet as a substitute for milk (up to 105 days) had similar results with milk feeding to calves without compromising growth rates (Table 3). There were no significant (P>0.05) differences between treatments implying that the formulated test diet (with CP 23% and ME approximately 11 Mj kg^{-1}) was comparable to milk feeding up to 105 days period. All calves in the experiment attained the expected daily weight gain of more than 0.5 kg^{-1} day recommended for well managed dairy farms (Odongo and Njuho, 1990).

However, there were differences (P<0.05) in DM intake of the basal diet (Table 3). The highest DM intake was registered in the EM fortified EWDs, while the other treatments had similar values as the control. The calves on this treatment appeared healthy, and thus feed intake was not reduced, unlike in other treatments. However, the observed increase in feed intake in this treatment did not result in increase in weight gains.

Economic performance. Adopting the early weaning technology using EWD up to 105 days, reduced the cost of rearing a dairy calf by approximately threefold (Table 4). Farmers can save 9 kg of milk per cow per day, compared to 5 kg in the control group (Table 4). Therefore, for a 105-day calf rearing period, the total milk saved (due to feeding of EWD) is 9 kg $cow^{-1}day^{-1}$ multiplied by 105 days = 945 kg of milk savings. At US$ 0.65 per kg of milk, the total savings would be valued at 945 kg milk multiply by 0.65 = US$614. For conventional milk feeding, the total milk saved is 5 kg cow^{-1} day^{-1} (Table 4). For a 105-day calf rearing period, the total milk saved in the control group would be 5 kg cow^{-1} day^{-1} multiply by 105 days = 525 kg. The monetary equivalent is = 525 kg multiply by US$ 0.65 = US$ 341. According to Staal *et al (*2001), farmers usually offer 4 kg of milk to calves per day in the smallholder dairy production systems. This mode of feeding releases more milk to the farmer for sale at the expense of the calf health, which may later die of malnutrition. A standard farm offers 6 kg of milk to calves per day. However, use of EWD allows the farmers to share milk equally with the calves during the first phase of lactation.

From the current study the use of early calves' weaning technology gives two major benefits; (i) an increase in available milk for sale home consumption and/or for sale; and (ii) positive performance of calves without any adverse effects. These findings are in agreement with those by Odongo and Njuho (1990) who reported 20% increase in household incomes when maize/ bean gruel was used to replace milk for dairy calves.

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REFERENCES

Anjum, A.D., Hussain, T. and Rizvi, F. 2006. Influence of effective microorganisms on health and immune system of broilers under experimental conditions. EM Technology Network Database, 2006.

Cremonini, F., Di Caro, S. and Nista, E.C. 2002. Meta-analysis: The effect of probiotic administration on antibiotic-associated diarrhoea. *Alimentary Pharmacology and Thereriology Journal* 16:1461 -1467.

D'Souza, A.L., Rajkumar, C., Cooke, J. and Bulpitt, C.J. 2002. Probiotics in prevention of antibiotic associated diarrhoea: Meta-

analysis. *Journal of Applied Bacteriology* 324: 1361.

Fuller, R. 1987. Probiotics in man and animals. *Journal of Applied Bacteriology* 66: 365-378.

Hagg, F.M., Lourens, E., Henning, P.H. and Coertze, R. J. 2012. The effect of a direct-fed microbial (*Megasphaera elsdenii*) on the productivity and health of holstein cows. *South African Journal of Animal Science* 40: 2-3.

Kehoe, S.I., Dechow, C.D. and Heinrichs, A.J. 2006. Effects of weaning age and milk feeding frequency on dairy calf growth, health and rumen parameters. http://www.doi:10.1016/j.livsci.2006.11.007. Accessed on 1/22/2007.

Khan, A.G. and Azim, A. 2000. Performance of early-weaned buffalo calves fed on lysine and methionine supplemented cottonseed meal. *Buffalo Journal* 3:381-386.

Khan, A.G., Azim, A. and Mirza, I.H. 2002. Response of feeding amino acids supplemented cottonseed meal on growth performance and digestibility of early-weaned cow calves. *Asian- Australasian Journal of Animal Science* 15: 184-187.

Land O' Lakes Inc. 2003. Testing and promoting silage making technologies in the smallholder dairy farmers in Kenya. First technical report. 38pp.

Odongo, E.N. and Njuho, P.M. 1990. The effect of mixture of milk and gruel on calf performance. *East African Agricultural and Forestry Journal* 56: 43-50.

Silva, A.G., Huber, J.T. and DeGregorio, R.M. 1986. Influence of substituting two types of soybean protein for milk protein on gain and utilisation of milk replacers in calves. *Journal of Dairy Science* 69:172.

Staal, S.J., Muriuki, H., Kenyanjui, M., Lukuyu, B., Njoroge, L., Njubi, D., Baltenweck, I., Musembi, F., Gichungu, G., Omore, A. and Thorp, W. 2001. Dairy systems characterisation of the greater Nairobi milk shed. Smallholder Dairy Project (SDP) research report, Ministry of Agriculture, Kenya Agricultural Research (KARI) and International Research Institute (ILRI), Nairobi, Kenya. 73 pp.