The effect of using different protein sources and high level of starch in milk replacers on the profitability of rearing Holstein bull calves

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Abstract

The economic viability of four milk replacers was evaluated to determine the most cost-effective option for rearing Holstein bull calves. Thirty-two (N = 32, n = 8) 3-5 day old calves with an average weight of 40.8kg were randomly assigned to one of four treatments (Biomel®, FP-Biomel, Kalfpap®, FP-Kalfpap) in a 63-day trial, during which the milk replacers were fed. Milk replacer intake was limited to 6L/calf/day, while starter meal was offered *ad libitum*, with all intakes and refusals recorded. Financial parameters calculated included total cost, average daily cost and income from the sale of calves at the end of the trial. All measured parameters differed between treatments. In terms of cost and average daily cost, treatment FP-Kalfpap was the most economical with the lowest average feeding cost for the trial at R2423.74/calf. However, for income which is influenced by growth performance parameters (calf weight, dry matter intake), Kalfpap® and FP-Kalfpap emerged as the most cost-effective and showed the highest return. Based on these results, Kalfpap® and FP-Kalfpap are recommended as the most cost-effective milk replacers.

Keywords: cost-effective, economic viability, growth performance, starter meal
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Introduction

Milk replacers refer to products that substitute or supplement mother's milk during the suckling phase of mammalian animals (Soberon *et al*., 2012) and are used to replace natural milk. They are therefore formulated to mimic the nutrient value of natural milk to ensure that adequate nutrients for the health and growth of suckling neonatal animals are provided (Palczynski *et al*., 2020). The use of milk replacers ensures a consistent supply of nutrients to young animals where the dam's milk is unavailable. They are also used to mitigate the risk of disease transmission from the dam to the offspring (Nielsen *et al.*, 2008; Van Niekerk *et al*., 2021) and are formulated to provide optimal growth, increase productivity and can provide a more flexible management option to farmers. According to Akins (2016), milk replacers can supplement mother's milk and partially replace it, providing farmers with a way to control the cost of rearing animals. As the milk composition of different species vary (Gantner, 2015), milk replacers are formulated to be specie specific, providing research and development opportunities.

The fact that different milk replacers influence growth rate and the incidence of diarrhoea in calves is well documented (Blome *et al.*, 2003; Amado *et al.*, 2019; Li *et al.*, 2019) and this effect differs depending on the specific rearing conditions. The biological and economic viability of a specific feeding regime depends on growth rate, feed conversion, cost of the milk replacer and the incidence of growth insults caused by factors such as diarrhoea (Wei *et al*., 2023).

One of the biggest challenges for this sector is the high production and retail cost of milk replacers (Carulla *et al.,* 2023). this problem is not exclusive to the South African milk replacer industry, its impact is significant, and affects both small scale farmers (Syomiti *et al.,* 2014) and large commercial producers (Sharpe & Heins, 2021). The high cost of milk replacers can be attributed to the expensive, high quality raw materials needed to produce it (McCoard *et al*., 2021). Since a significant amount of milk replacers used in Southern Africa is developed and manufactured in first world countries, the unfavourable exchange rate further exacerbates cost challenges for using imported milk replacers in the local market (Aron *et al.,* 2014). Compared to the global market, the South African milk replacer market is relatively small. In monetary terms, the South African milk replacer market was estimated at between R30 and R35 billion per annum (Grobler, 2008). However, due to constantly changing economic environment and the lack of data, the value may be significantly different.

To provide more affordable options to farmers, alternative sources of affordable raw materials are required (Bezuidenhout *et al.*, 2019). Therefore, Kertz *et al*. (2011) proposed that research should be conducted on more affordable and higher quality milk replacers. The use of different protein sources and different energy sources impact on the growth performance and cost of rearing calves. Thus, Kriel (2025) conducted a study on alternative sources of affordable raw materials in milk replacers, investigating fermented protein (FP-Biomel, FP-Kalfpap) and high starch milk replacers (Kalfpap®, FP-Kalfpap). The goal of this study was to develop affordable milk replacers that still provided optimal growth performance when rearing calves. Kriel (2025) reported that milk replacers containing fermented protein performed poorly due to high levels of trypsin inhibitor, therefore unless fermented protein is treated to reduce the trypsin inhibitor levels to lower than 4 mg/g protein (Lalles *et al*., 1996), it should not be included in milk replacers for neo-natal calves. Kriel (2025) also confirmed that high starch milk replacers can be used and that growth performance is equal to that of a conventional milk replacer (Biomel®). It was concluded that the feeding of high starch milk replacers had an additional benefit in that it stimulated starter meal intake (Kriel, 2025).

The aim of this article is to investigate the economic viability of the milk replacers (Biomel®, FP-Biomel, Kalfpap®, FP-Kalfpap) after growth performances was ensured by Kriel (2025). Fermented protein (Nandrea Health Products) and high starch content in milk replacers has a lower cost than the raw materials in conventional milk replacers thus providing potential less expensive milk replacer substitutes.

Materials and Methods

Ethical clearance for this study was obtained from the University of the Free Sate Animal Research Ethics Committee for all trial related practices (UFS-AED2023/0051).

The financial aspects and the cost benefit analysis of two registered milk replacers (Biomel® and Kalfpap®) and two newly developed milk replacers (FP-Biomel and FP-Kalfpap) were the focus of this investigation. The biological effect of higher starch levels and fermented protein of theses milk replacers on growth performances parameters weight, dry matter intake, average daily gain, dry matter intake per body weight percentage and feed conversion ratio were reported (Kriel, 2025).

Table 1 The four milk replacers treatment (n = 8/treatment) with a total of 32 calves

	Standard protein (SP)	**Fermented protein (FP)**
Standard starch inclusion levels	Biomel®	FP-Biomel
Higher starch inclusion levels	Kalfpap®	FP-Kalfpap

Thirty-two Holstein bull calves (with an average weight of 40.8kg), supplied by a commercial supplier, were marked with different numbered colour tags and randomly allocated to the respective treatment groups. All the calves received colostrum immediately after birth and entered the trial at an age of between 3 and 4 days. Calves fed the high starch milk replacers (Kalfpap® and FP-Kalfpap) were gradually transitioned from standard milk replacer to the high starch milk replacers. This was done to limit the incidence of diarrhoea due to a change in the diet. During the current trial this transition started with the inclusion of 25% starch milk replacer on day 11 and was increased in fractions of 25%, reaching 100% on day 14. Table 2 show the milk replacer feeding regime during the trial.

Calves had *ad libitum* access to starter meal and any refusals were noted, and total intake was compounded on a weekly basis.

Day 11-13 (Table 2) shows the transition phase to high starch milk replacers for Kalfpap® and FP-Kalfpap. Calves fed the high starch milk replacers were gradually transitioned from standard milk replacer to the high starch milk replacers. This was done to limit the incidence of diarrhoea due to a change in the diet. It is well documented that when calves are 11 days old the activity levels of starch digestive enzymes including amylase, maltase and isomaltase should have increased to such an extent that it is possible to successfully introduce high starch milk replacers (Miyashige & Yahat, 1980; Harmon, 1993). Harmon (1993) further concludes that the secretion and activity of amylase activity can be manipulated nutritionally. This transition is important as it has a direct bearing on the total cost of weaning a calf.

Table 2 The milk replacer feeding regime during the trial

Day	Milk replacer treatment				Intake
1	Biomel® n = 16		FP-Biomel n = 16		1L/feeding/calf 3 feedings/day
2-4	Biomel®		FP-Biomel		1.2L/feeding/calf 3 feedings/day
5-7	Biomel®		FP-Biomel		1.4L/feeding/calf 3 feedings/day
8-10	Biomel®		FP-Biomel		1.6L/feeding/calf 3 feedings/day
11	Biomel® n = 8	25% Kalfpap® 75% Biomel n = 8	FP-Biomel n = 8	25%FP-Kalfpap® 75% FP-Biomel n = 8	1.8L/feeding/calf 3 feedings/day
12	Biomel®	50% Kalfpap® 50% Biomel	FP-Biomel	50% FP-Kalfpap® 50% FP-Biomel	1.8L/feeding/calf 3 feedings/day
13	Biomel®	75%Kalfpap® 25% Biomel	FP-Biomel	75% FP-Kalfpap® 25%FP Biomel	1.8L/feeding/calf 3 feedings/day
14-58	Biomel®	Kalfpap®	FP-Biomel	FP-Kalfpap	2L/feeding/calf 3 feedings/day
59-60	Biomel®	Kalfpap®	FP-Biomel	FP-Kalfpap	2L/feeding/calf 2 feedings/day
61-63	Biomel®	Kalfpap®	FP-Biomel	FP-Kalfpap	1L/feeding/calf 2 feedings/day

Milk replacers cost calculation were calculated according to the treatments in the rows. Therefore, treatments that consisted of more than one milk replacers were calculated using both prices. As the use of these treatments will always have a transition phase in practical circumstances.
Any milk replacer refusals were noted, and total milk intake was compounded on a weekly basis.

To ensure that the end product correlated with formulations, random samples of milk replacers and the starter meal were collected for proximate analysis. Milk replacers were formulated on an iso-caloric and iso-nitrogenous basis. The protein content was determined according to standard methods prescribed by AOAC (2002) using the Dumas method and a LECO FP828 (St Joseph, MI, USA). The average metabolic energy of the milk replaces was 12.44 MJ/kg and with a crude protein content of 201.25 g/kg. The crude fat content of the milk replacers was gravimetrically determined by Assurecloud, (Evers *et al.*, 2000). Biomel® and FP-Biomel had an average crude fat of 157.3 g/kg and 115.85 g/kg for Kalfpap® and FP-Kalfpap. A standard commercial starter meal with a metabolizable energy content of 10.57 MJ/kg, crude protein of 154.4 g/kg and crude fat content of 3.2 g/kg was used. Crude fat content adhered to general guidelines for ruminating cattle (Fiorentini *et al.*, 2015; Bionaz *et al.*, 2020).

A standard vaccination program was followed, and calves were weighed on a weekly basis. Table 3 shows the prices per kg milk replacer (February 2024) as provided by Nandrea Health products, as well as the prices per kg of the starter meal. The sale price of calves used in calculations was obtained from the Red Meat Producers Organisation (RPO) price on 10/03/2024.

The financial viability of the different treatments was evaluated using a cost benefit analysis. For analysis of the different milk replacers' financial data, a one-way ANOVA was used. Significant difference was declared at $P \leq 0.05$ and tendencies at $P \leq 0.10$.

Table 3 The prices used when calculating the parameter used in the cost benefit analysis (Nandrea Health Products; RPO)

Item	R/kg
Biomel®	58.25
FP-Biomel	50.47
Kalfpap®	47.95
FP-Kalfpap	39.20
Starter meal	7.53
Live weight	36.11

Results and Discussion

The effect of the different milk replacers on profitability parameters of calves are shown in Table 4. The parameters reported include cost, average daily cost (ADC) and income, based on the economic value of the calves at weaning. All cost benefit parameters reported had $P < 0.05$ leading to the rejection of the null hypotheses. This implies that groups in rows were not significantly equal.

Table 4 The effect (mean ± SE) of milk replacer on profitability parameters of calves expressed in terms of ZAR for a 63-day trial.

Parameter (R/calf)	Treatment (LS Mean ± Standard deviation)				P-value
	Biomel®	FP-Biomel	Kalfpap®	FP-Kalfpap	
Cost MR & SM	3342.20^{a} ± 156.56	2757.75^{c} ± 61.59	2957.23^{b} ± 82.67	2423.74^{d}± 132.99	<0.001
Cost MR	3037.05^{a} ± 62.53	2636.14^{b} ± 55.97	2593.38^{b} ± 48.94	2180.29^{c} ± 62.00	<0.001
Cost SM	305.15^{ab} ± 132.50	121.61^{c} ± 66.06	363.85^{a} ± 71.09	243.45^{b} ± 136.18	<0.001
ADC	53.05^{a} ± 2.49	43.77^{c} ± 0.98	46.94^{b} ± 1.31	38.47^{d} ± 2.11	<0.001
Income*	-840.41^{b} ± 328.70	-1031.43^{b} ± 397.40	-459.05^{a} ± 148.08	-293.88^{a} ± 463.84	<0.001

MR: Milk replacer; SM: Starter meal; ADC: Average daily cost

$^{a, b, c}$ Means within row with different superscripts differ significantly ($P < 0.05$).

* Income is the price of dry matter intake (MR & SM) and the initial cost calf subtracted from the prices of the final weight of the calf. Although standard deviation is large there were no outliers in the data.

Cost was calculated as the amount spent for milk replacer and starter meal and is therefore specific to this trial. In different commercial systems the rearing period may differ depending on specific rearing conditions and practices. Further, external market forces can affect profitability parameters (Cortéz & Manual, 2010). Average daily cost (ADC) gives an indication of the cost per day, and this is a useful tool when managing a calf unit and for the development of budgets. Cost and ADC will therefore follow the same trend.

Since milk replacer intake was regulated, the difference in cost is therefore a function of milk replacer price and not intake. Calves drank an average on 5.5 L/calf/day having an average milk replacer dry matter intake of 827.87g/calf/day. Regarding milk replacer cost, Biomel® had the highest cost at R 3037.05 and FP-Kalfpap had the lowest cost at R2180.29 ($P < 0.05$). The cost of FP-Biomel and Kalfpap® did not differ from each other but differed ($P < 0.05$) from Biomel® and FP-Kalfpap (Table 4).

As the same starter meal was used for all the treatments, differences in starter meal cost were determined by variance in intake and not prices as is the case with milk replacers. Therefore, these values follow the same trend as starter meal intake, Kalfpap® had the highest average starter meal intake 5,369kg/calf/day and Biomel® followed with 4.503kg/calf/day. This is reflected in cost of starter meal intake where Kalfpap® and Biomel® did not differ with the highest cost. FP-Kalfpap starter meal cost did not differ from Biomel® but did differ from Kalfpap®, with an average starter meal dry matter intake of 3.592kg/calf/day and therefore an average cost of R243.45/calf for the trial period. FP-Biomel differed from all other treatment ($P < 0.05$) with the lowest starter meal cost of R121.61/calf for the trial period and an average intake of 1.794kg/calf/day.

The lowest combination (MR & SM) cost was FP-Kalfpap at R2423.74/calf for the trial period with an ADC of R38.47/calf. As a higher intake is advantageous as it leads to improved growth the lower cost is not necessarily favourable. This contrast greatly with Biomel® which had the highest combination cost at R3342.2/calf for the trial period and an ADC of R53.05/calf. Kalfpap® had a combined cost of R2957.23/calf for the trial period and ADC of R46.94/calf and FP-Biomel had a combined cost of R2757.75/calf for the trial period and ADC of R43.77/calf.

As income is dependent on the weight of the animal and therefore growth rate (given the starting weight is similar), this parameter provides the best indication of the efficacy of a specific feeding regime. Income is the profit made after subtracting the purchase price (R360) and feeding cost from the selling price of the calf. This is deemed to be the best parameter to determine cost benefit. However, income is based on the specific trial conditions and may not be directly applicable to large-scale commercial units although it is expected that the trend will remain the same. In these units weaning generally forms part of an extended production process and although cost is carefully managed, profit is mostly generated by weight gain during the back grounding phase where the weaned calves are normally fed grazing until they reach a weight of between 220 and 240 kg before they are placed into a feedlot (Blom *et al.*, 2022). Therefore, the trends are arguably more important for this parameter than the actual values. Kalfpap® and FP-Kalfpap had the highest income compared to Biomel® and FP-Biomel which had the lowest income.

Conclusions

When only considering the cost of milk replacers and the starter meal FP-Kalfpap had the lowest cost with an average daily cost of R38.47/calf. However, when considering income which is the best parameter to determine cost benefit of a treatment, Kalfpap® and FP-Kalfpap performed best. In the same study Kriel (2025) found that milk replacers containing fermented protein performed poorly due to high levels of trypsin inhibitor, therefore unless fermented protein is treated to reduce the trypsin inhibitor levels to lower than 4 mg/g protein (Lalles *et al*., 1996), it should not be included in milk replacers for neo-natal calves. Thus, the Kalfpap® would be the recommended milk replacers.

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Conflict of interest declaration

None of the authors have a conflict of interest.

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