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PRE- AND POST-WEANING PERFORMANCE OF ARTIFICIALLY REARED CALVES

1. HIGH AND LOW FAT LEVELS IN MILK REPLACERS AND CEMENT KILN DUST AS AN ADDITIONAL SOURCE OF MINERALS IN STARTER MEALS

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OPSOMMING: VOOR- EN NASPEENPRESTASIE VAN KUNSMATIG GROOTGEMAAKTE KALWERS
1. HOË- EN LAE-VETPEILE IN MELKVERVANGERS EN SEMENT OONDSTOF AS 'N ADDISIONELE BRON VAN MINERALE IN AANVANGSMELE

Vier-en-twintig Fries kruis-kalwers is kunsmatig in 'n 2^2-faktoriale proefontwerp grootgemaak vir 'n periode van 13 weke. Die twee faktore en peile van behandeling was (1) die vet inhoud van die melkvervanger, naamlik 20,8 persent (F_1) of 12,6 persent (F_0) op 'n lugdroë basis en (2) die hoeveelheid sement oondstof (cement kiln dust) bygevoeg tot die kalfaanvangsmeel, naamlik 3,5 persent (C_1) of 0 persent (C_0) van die lugdroë rantsoen. Die gemiddelde massatoename oor die speenperiode vir die groep kalwers wat die hoë-vet (F_1) melkvervanger ontvang het, was betekenisvol hoër as die wat die lae-vet (F_0) ontvang het, naamlik: week 7 ($P < 0{,}01$), week 8 ($P < 0{,}001$) en week 9 ($P < 0{,}01$). Droëmateriaalinname op speenouderdom was ook betekenisvol groter ($P < 0{,}05$) vir die F_1 groep teenoor die F_0 groep. Oor die hele proefperiode het die totale toename in liggaamsmassa en voeromsetting vir hierdie twee groepe ook betekenisvol verskil (58,71 kg en 2,15 vs. 50,14 kg en 2,47; $P < 0{,}05$ en $P < 0{,}01$ onderskeidelik). Alhoewel daar geen betekenisvolle verskil in lewende massa op enige stadium tussen die C_1 en C_0 groepe was nie, was die droëmateriaalinname van die C_0 groep op speenouderdom betekenisvol groter ($P < 0{,}05$) as dié van die C_1 groep. Op hierdie ouderdom was daar ook 'n betekenisvolle ($P < 0{,}05$) interaksie in beide droëmateriaalinname en lewende massatoename by die F_1C_1 groep. Die vetinhoud van die melkvervanger het 'n betekenisvolle invloed op die voorkoms van diarree gehad, met die hoogste insidens onder die kalwers wat die lae-vet melkvervanger ontvang het.

SUMMARY:

Twenty-four Friesland-cross calves were reared artificially in a 2^2-factorial experimental design for a period of 13 weeks. The two factors and levels investigated were (1) the fat content of the milk replacer, viz. 20,8 per cent (F_1) or 12,6 per cent (F_0) on an air-dry basis and (2) the amount of cement kiln dust added to the calf starter meal, viz. 3,5 per cent (C_1) or 0 per cent (C_0) of the air-dry ration. The average live mass gain over the weaning period for the group of calves receiving the high-fat (F_1) milk replacer was significantly higher than those receiving the low-fat milk replacer, viz: week 7 ($P < 0{,}01$), week 8 ($P < 0{,}001$) and week 9 ($P < 0{,}01$). Dry matter intake at weaning age was also significantly greater ($P < 0{,}05$) for the F_1 group as compared to the F_0 group. Over the entire experimental period the total live mass gain and feed conversion ratio for these two groups also differed significantly (58,71 kg and 2,15 vs. 50,14 kg and 2,47; $P < 0{,}05$ and $P < 0{,}01$ respectively). Although there were no significant differences in live mass gain at any stage between the C_1 and C_0 groups, the dry matter intake of the C_0 group at weaning age was significantly higher ($P < 0{,}05$) than that of the C_1 group. At this age there was also a significant ($P < 0{,}05$) interaction in both dry matter intake and live mass gain in in the F_1C_1 group. The fat content of the milk replacer had a significant influence on the occurrence of diarrhoea – the highest incidence occurring amongst the calves receiving the low fat diet.

The artificial rearing of calves on diary farms either for heifer replacements or for veal production can, depending on the cost of the milk replacer used and the calf mortality rate, be a profitable supplementary enterprise. As all milk replacers contain at least 20 per cent protein, the cost per kg of commercial milk replacer depends on its fat content (which varies from 5 – 25 per cent) and increases with increased fat percentage. Liebenberg and Van der Merwe (1974) have however shown that although an increase in the fat content of milk diets resulted in increased live mass gains in calves, it also resulted in an increased incidence of scours when fat in milk diets exceeded 50 per cent of the dry matter. It is today generally accepted that the direct cause for a high calfhood mortality rate is diarrhoea, whether nutritional or otherwise. According to a few pilot surveys made in South Africa a death rate of 20 – 40 per cent has been recorded in some areas (Henning, 1962).

Interest in this subject has resulted in extensive research on the one hand on such nutritional aspects as the utilization and effect of either whole milk or milk replacer (with or without varying amounts of fat) on the pre- and post-weaning performance of calves (Neville, McCullough, Sell & Baird, 1952; Khouri & Pickering, 1968; Roy, 1970; Liebenberg & Van der Merwe, 1974) and on the other hand to veterinary aspects such as the causes, effects, prevention and treatment of diarrhoea in calves (Lewis & Phillips, 1972; Mebus, Stair, Rhodes, Underdahl & Twiehaus, 1973; Lewis, Phillips & Elliot, 1975; Radostits, Rhodes, Mitchell, Spotwood & Wenkoff, 1075; Frank, 1976).

Systems for hand-raising calves economically in South Africa are still far from perfect and the results reported in this paper are presented as one of a series of systematic investigations into the subject with a view of improving existing systems. With the high cost of milk and of milk replacers, the early weaning system is used and is based on the stimulation of rumen function in the young calf at the earliest possible stage. However, calves in this system are confined for long periods of time and have little access to soil. Ingested soil can be a source of several essential mineral elements (Healy, 1970) and can also affect the availability of dietary elements in the digestive tract (Healy, 1972; Grace & Healy, 1974).

A first aim was to determine the effect of a high fat (20,8 per cent) commercial milk replacer (formulated specifically for lambs) on the performance of early weaned calves as measured by their live weight gain, feed conversion rate and incidence of scours as opposed to the performance of those fed one of the commercial calf milk replacers containing 12,6 per cent fat.

In view of the promising results obtained by Wheeler and Oltjen (1977) and Genis (1978) with the inclusion of cement kiln dust (which consists chiefly of the oxides of a number of macro- and trace elements) in the diets for finishing steers, a second aim of the present study was to determine whether similar results could be achieved in the young ruminant. Wheeler and Oltjen (1977) reported a 27,9 per cent higher ($P<0,05$) average daily gain and a 20,8 per cent improved ($P<0,05$) feed conversion rate in steers fed the cement kiln dust than those fed the control diet.

Procedure

Twenty-four Friesland-cross calves obtained from a local dairy with an average age of one to two weeks and with a mean weight of 42,48 ± 5,80 kg were allotted at random to four treatment groups in a 2^2-factorial design experiment. The two factors and levels investigated were (1) the fat content of the milk replacer allowed per calf, viz. a 20,8 per cent (F_1) or 12,6 per cent fat (F_0) on an air-dry basis and (2) the amount of cement kiln dust added to the calf starter ration, viz. at 3,5 per cent (C_1) or 0 per cent (C_0) of the air-dry ration.

The system used for raising calves artificially in this study is similar to that proposed by Van der Merwe (1977) but with a few minor modifications. The commercial milk replacers (Nukamel R^{11} and Wessalam) used in the two levels investigated were reconstituted to contain 15 per cent total solids (i.e. 150 g dry milk powder per liter) prior to each feeding using hot water and fed warm to each calf individually by means of a bucket. Each calf in all four treatment groups were fed at 8 per cent of body mass during the first two weeks (week 1 and 2), at 10 per cent of body mass during the following two weeks (week 3 and 4) and thereafter at five per cent of body mass until weaned. Initially, the calves were fed twice daily, but feeding was reduced to once daily when milk was fed at the five per cent body mass level. The chemical composition of the milk replacers were determined in a commercial laboratory* and are presented in Table 1.

Table 1

The chemical analysis of the high and low fat milk replacers

Item		High fat (Wessalam)	Low fat (Nukamel R^{11})
Moisture	%	3,7	4,5
Fat (tri)	%	10,9	6,8
Fat (trico)	%	20,8	12,6
Ash (550°C)	%	6,8	7,7
Crude Protein	%	24,7	24,6
Starch (EEG)	%	2,2	3,8
Iron (direct)	ppm	42	12
Iron (after incineration)	ppm	51	12
Copper (after incineration)	ppm	3	18
pH		6,55	6,40
Glucose	%	–	–
Lactose (after fermentation)	%	40,9	48,1
Calcium	%	0,96	0,93
Phosphorus	%	0,8	0,8
Cl as NaCl	%	2,0	2,7
Vitamin A*	i.u./kg	30 000	20 000
Zink Bacitracin*	ppm	88	66

*Items not analyzed but guaranteed to contain the stated amounts by the manufacturers.

Water and the calf starter meal was supplied *ad lib.* and was made available after the first week. The calves

**Wessanen Royal Mills, Wormerveer, Netherlands.*

remained in individual raised pens* throughout the experiment (which lasted 13 weeks), except on weight recording days, when they were released into an open communal run for two to three hours. Calves were weighed regularly at weekly intervals and the meal consumed by individual calves was recorded daily. Weaning, which was adrupt, took place when calves consumed 0,7 kg/day or more of the meal on three consecutive days and had reached a mass of at least 70 kg.

The calf starter meal presented was formulated using NRC (1971) requirements for growing calves up to the age of 12–13 weeks. The ingredients and amounts used were based on the recommendations of Van der Merwe (1977). A chemical analysis of this starter meal was obtained from the Department of Animal Husbandry of the University of Pretoria. Six calves of the high fat (F_1) group and six calves of the low fat (F_0) group obtained a ration consisting of 96,5 per cent of the starter meal and 3,5 per cent cement kiln dust (C), deviding the experimental animals into four groups, viz.: C_0F_0, C_0F_1, C_1F_0 and C_1F_1. Except for the extra minerals provided by the added kiln dust, this starter meal therefore provided only 96,5 per cent of the nutrients supplied at the other level. The ingredients and composition of both starter meals together with their chemical analyses are presented in Table 2.

Table 2

Composition and analysis of the starter meals and their calculated digestible energy content

Item	Calf starter meal No kiln dust Per cent	 Kiln dust Per cent
Ingredient:		
Yellow maize meal	66,0	63,69
Soyabean oilcake meal	16,0	15,43
Fish meal	6,0	5,78
Lucerne meal	11,0	10,60
Mineral premix*	1,0	1,0
Cement kiln dust	–	3,5
Chemical analysis:		
Dry matter	89,6	89,90
Crude protein	14,94	14,42**
Crude fibre	5,22	5,04**
Crude fat	4,73	4,56**
Ash	7,26	9,29**
Calcium	0,898	1,594**
Phosphorus	0,671	0,726**
Digestible energy (MJ/kg)	13,998	13,508

* The mineral premix consisted of 50 per cent finely ground stock salt and 50 per cent Fermafos-12P (a commercial phosphate-trace element mixture).
** Calculated analysis

The cement kiln dust used in this study was obtained from Pretoria Portland Cement Company which also supplied a mineral analysis of the macro elements. Trace elements were determined by a commercial laboratory**. The complete mineral analysis is presented in Table 3.

Table 3

Mineral analysis of cement kiln dust

Item	Composition* Per cent
Calcium	30,59
Phosphorus	0,04
Sodium	0.07
Potassium	1,95
Magnesium	1,19
Iron	0,83
Sulphur	0,63
Silicon	4,73
Aluminium	1,26
Manganese	0,28
Titanium	0,06
Chlorine	1,67
	mg/kg
Copper	83
Cobalt	15
Zinc	89
Selenium	25
Molybdenum	10
Strontium	970
Cadmium	3
Arsenic	15
Lead	50
Chromium	115
Mercury	0,7

*Dry matter basis

All calves were subjected to a standard treatment during the first few days of the experiment. On arrival each calf received a single intramuscular injection of 250 000 i.u. vitamin A, 70 000 i.u. vitamin D and 70 i.u. vitamin E (Pfizer) and an oral spray of 2 ml oxytetracycline HC 1 (Liquamycin-100). On each day for four consecutive days, starting from day 1, each calf received 20 g oxytetracycline HC 1 powder (Pfizer) per day via the milk and 8 g of a coccidiostat (Amprol RH) approximately two hours after the morning feeding.

**Manufactured by HGF Engineering, Johannesburg.*

***Bergström and Bakker, Bedfordview, Johannesburg.*

After an elapse of four days each calf received 500 g Furanicol (Centaur) per day for another four consecutive days. Thereafter the calves that scoured were treated individually with either antibiotics and/or sulpha drugs. The incidence of diarrhoea was recorded daily for the two levels of milk replacer treatments. Although various degrees of scouring were noted, the criterium used for recording whether a calf was scouring or not was a subjective one, viz. the decision to treat the calf for scours or not.

Results and Discussion

The means and standard deviations of the four treatment groups F_0, F_1, C_0 and C_1 and the standard error of these means for live mass gain, dry matter intake and feed conversion are presented in Table 4. All the data for the above-measured variables were subjected to analyses of variance (Ridgman, 1975). Unfortunately one calf in the F_0C_0 group died at the beginning of week 12 as a result of bloat.

From the results of the analysis of variance for live mass gain it was found that the calves receiving the high-fat milk replacer performed significantly better than those on the low-fat diet. Not only did they gain more weight by the time they were weaned, viz. 26 per cent at the end of week 7 ($P<0{,}01$), 27 per cent at the end of week 8 ($P<0{,}001$) and 19 per cent at the end of week 9 ($P<0{,}01$), but were able to maintain this advantage to the end of the experimental period (week 13) at which stage they had gained 17 per cent more ($P<0{,}05$) weight than the low-fat group (58,71 ± 8,44 kg versus 50,14 ± 7,62 kg). Expressed in g/day, the live mass gains for the total experimental period were 551 ± 83 and 645 ± 93 for the low- and high-fat groups (F_0 and F_1) respectively.

Calves fed the high-fat milk replacer consumed significantly ($P<0{,}05$) less dry matter at weaning age than those receiving the low-fat milk replacer (Table 4). At the end of the treatment period there was no significant difference for dry matter intake between the two groups with the result that the high-fat group achieved a significantly ($P<0{,}01$ better feed conversion ratio at week 13. Where supplementary feeding of dry concentrate is being provided on an *ad lib.* basis there is evidence that an increase in the level of fat in the milk replacer can lead to reduced consumption of the dry concentrate (Raven, 1970). Griffiths and McGann (1966) have also found that calves receiving a low-fat milk replacer consumed more concentrate than calves receiving a high-fat milk replacer. The better feed conversion ratio could be attributed to the higher fat content of the milk replacer. According to Raven (1970)

Table 4

Means and standard deviations of treatment groups with standard error of means

	Milk Replacer Means ± S.D.		± S.E.	Cement kiln dust Means ± S.D.		± S.E.
Treatment	$F_0C_0 + F_0C_1$	$F_1C_0 + F_1C_1$		$C_0F_0 + C_0F_1$	$C_1F_0 + C_1F_1$	
	F_0	F_1		C_0	C_1	
Pre-weaning live mass gain (kg)						
week 7	28,58 ± 6,39	35,96 ± 4,87	1,64	32,75 ± 5,11	31,71 ± 8,26	1,98
week 8	32,25 ± 6,51	40,88 ± 4,77	1,65	36,92 ± 4,09	36,21 ± 9,42	2,10
week 9	36,92 ± 6,72	43,88 ± 7,99	2,07	38,58 ± 4,35	42,25 ± 10,15	2,25
Post-weaning live mass gain (kg)						
Total experimental period	50,14 ± 7,62	58,71 ± 8,44	2,43	52,79 ± 6,96	56,59 ± 10,81	2,71
Dry matter intake (kg)						
At weaning age	62,91 ± 9,13	56,71 ± 4,99	2,12	56,77 ± 6,99	62,84 ± 7,79	2,14
Total experimental period	123,70 ± 20,83	125,43 ± 16,04	5,57	121,17 ± 20,48	125,07 ±16,03	5,58
Feed conversion						
(kg Dm-intake/kg gain)	2,47 ± 0,23	2,15 ± 0,19	0,06	2,35 ± 0,25	2,25 ± 0,28	0,08

addition of fat leads to a marked increase in energy value which undoubtedly brings about substantial improvements in growth rate and efficiency of feed conversion.

No significant difference was found between the calves fed the cement kiln dust and those receiving no kiln dust and it is evident that the kiln dust in the diet of the young ruminant has not influenced performance to the extent found by Wheeler and Oltjen (1977) with mature steers. The 3,5 per cent difference in protein and energy content between the two rations is not significant, but because of certain properties of the kiln dust, further investigation into this aspect seems justified.

Kiln dust is different from most conventional mineral ingredients for livestock because of the extremely high temperatures (1500°C) to which it is exposed. These temperatures could increase the availability of several mineral elements to the animal. Also the extreme fineness of the kiln dust could have some influence on the availlability of the minerals. Cement kiln dust has a particle size of less than six micrometers (Greening *et al.*, 1973) and consequently an enormous surface area available for chemical reactions.

The chemical analysis of the kiln dust shows that it is a complex blend of mineral elements (Table 3). Several of these elements are known to be essential for ruminant animals (NRC, 1976). However, Hubbert *et al.*, (1958) and Bryant *et al.*, (1959) have found trace minerals which are not required by the ruminant animal but are essential for maximum growth of several species of rumen micro-organisms. It could be that there are trace elements present in cement kiln dust which stimulate the growth and multiplication of rumen micro-organisms. This theory (Wheeler & Oltjen, 1977) is substantiated by the significantly higher ($P<0{,}05$) dry matter intake (Table 4) at weaning age of the calves fed the kiln dust to those not receiving it.

A significant interaction between the high-fat milk replacer and kiln dust starter meal was found at the end of week 8 ($P<0{,}05$) and week 9 ($P<0{,}01$) for live mass gain, but no significant interaction for dry matter intake and feed conversion ratio at any stage.

The incidence of scouring (measured as the number of calves that scoured or did not scour over a 60 day period) together with a chi-square evaluation of the results are presented in Table 5 for the two levels of milk replacer and cement kiln dust studied.

The results show that the level of fat played a significant role in the occurrence of scours amongst the calves, with the highest incidence occurring amongst the calves receiving the low-fat diet. Although the results reported by Liebenberg and Van der Merwe (1974) are not directly comparable with the results reported in this paper, it is interesting to note that the abovementioned authors found that scouring again became a problem when fat made out more than 50 per cent of the dry matter of the diet. The cement kiln dust on the other hand had no effect on the occurrence of scours.

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Table 5

The incidence of scouring at the two levels of milk replacer and cement kiln dust over a period of 60 days

Milk replacer				Cement kiln dust			
	Number of calves with scours	Number of calves without scours	Total		Number of calves with scours	Number of calves without scours	Total
High fat (F_1)	22	698	720	Kiln dust added (C_1)	62	658	720
Low fat (F_0)	103	617	720	Without kiln dust (C_0)	63	657	720
Total	125	1 315	1 440	Total	125	1 315	1 440
Chi-square = 57,48 ($P<0{,}001$)				Chi-square = 0,009 ($P<0{,}90$)			

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