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The effect of different milk replacers on Holstein calf performances, health, blood parameters, and economy

Abstract

This study was aimed to compare two different milk replacers (MR 22-18 (protein-fat), and MR 21-17 (Protein fat, LACALF)) instead of whole milk on calf growth performance, blood parameters, and economy. 42 Holstein calves born between November 2021 and May 2022 on an intensive dairy farm in the Mediterranean area were employed for this purpose. The calves were distributed in the control (whole milk), milk replacer 22-18, and milk replacer 21-17 groups, with the mean of gender and birth weights being similar for each group. The calves were kept together with their mothers for the first 3 days after birth to ensure that they received sufficient *colostrum* under similar farm conditions. Beginning from the second week, the calves were given free alfalfa hay and calf starter feed. After the calves consumed the liquid feed, their buckets were kept filled with water throughout the day and they were provided with free clean water. Body weight, feed consumption, body measurements, and blood samples were taken from each group of calves twice at the beginning and end of the trial. The results showed that MR 21-17 resulted similar in calf performance with whole milk, but MR 22-18 had lower growth performance compared to milk and MR 21-17 as MR 22-18 was contained higher fat and protein than MR 21-17. MR 21-17 has also lower feeding cost compared to whole milk and MR 22-18. The performance results revealed that milk replacer ingredient quality is main issues for effective calf growth.

Keywords: calf rearing, milk replacer, growth performance, blood parameters, economy

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Introduction

The sustainability of animal husbandry depends on the number of calves obtained annually and production with the minimum loss. The number of calves obtained in a farm shows the result of the farm practices. Care, feeding, and management from weaning to calf health and development are of critical importance.[1] In addition, calf performance in the pre-weaning period is also effective on the age of reaching puberty and mature performance. In addition, economic decisions taken in addition to livestock practices during this period increase the profitability of the farm. Newborns can only digest protein sources of milk origin due to the undeveloped digestive system. Considering these issues, more successful and economic calf-rearing systems are sought. Studies have shown that milk replacers can be substituted for whole milk in calf rearing.

Milk replacer feeds are designed with the use of milk powder, whey, and butter by-products, vegetable and animal oils, vitamins, and minerals.[1] A quality milk replacer feed specially formulated to meet the needs of animals is advantageous because it is cheaper than milk and does not carry the risks (containing antibiotics, carrying disease factors, etc.) of waste milk.[2,3] A good milk replacer is usually obtained by adding animal and vegetable fat sources, vitamins, and minerals to the by-products left over from processed milk. Milk powder contains 36-40% lactose, 30-40% fat, and 28-32% milk protein in dry matter. Whey proteins contain albumin and globulin, although the protein is principally derived from casein. A high-quality milk replacer should contain less than 0.1% crude cellulose. Typical milk replacer should contain 70-80% dairy by-products, 17-20% animal and vegetable fats, 2% lecithin, trace elements, and vitamins.[4]

Calf rearing studies with milk replacer started in the 1940s, and the first milk replacer was introduced to the market in 1951.[4] Milk replacer feed, which is used in approximately 60% of America, is the most commonly used and economical feed type after waste milk on large farms.[5] Young calves can only digest protein sources from dairy products until their digestive systems have developed. Production stages and quality of these products also affect performance due to calf digestion. Obtaining the protein used in milk replacer production by excessive heat application affects replacer coagulation negatively. This is not the case with the proteins obtained by the spray-drying method. Therefore, it provides healthier digestion. Today, milk replacers are sold on the market with different raw materials and methods. For this reason, it can be seen that there are contradictory results in the research results. There are many studies[5–12] reporting positive results on calf rearing with milk substitutes.

Milk replacers, which can be used as an alternative to milk, which is the biggest gain for dairy enterprises, is a feeding strategy that can keep the business alive by reducing operating costs.[6,10,11] In addition to its economic dimension, milk replacers help to prevent diseases that can be transmitted from mother to offspring in the enterprise, early development of calves, meeting the energy need by adjusting the metabolic energy level of the nutrient given in cold weather, minimizing the cases such as diarrhea, recording the amount of food consumed by the animals, and the use of feed additives.[5,12] There has been an increased interest in the use of milk replacer due to its advantages such as being easily added. Considering the income that milk provides for human nutrition and livestock enterprises in recent years, liquid feeding methods that will not cause negative effects on the development of calves have come to the fore.

This study, it was aimed to compare the effects of using two different milk replacers (MR) instead of whole milk on calf growth performance, blood parameters, and farm economy.

Material and methods

This study was carried out with a total of 42 Holstein calves born in an intensive dairy farm with a capacity of 200 milking cows between November and May 2021, 2022 in Adana. The calves were distributed in the control, MR 22-18 (22 protein-18 fat), and MR2 (21 Protein fat, LACALF) groups, with the mean of gender and birth weights being similar for each group. The calves were kept together with their mothers for the first 3 days after birth to ensure that they received sufficient colostrum under similar farm conditions. The calves were housed with their mothers for the first 3 days after birth, and then they were fed two meals a day in buckets in a special 8-week program with 224 L liquid feed in both groups (Table 1).

Beginning from the second week, the calves were given free alfalfa hay and calf starter feed (Table 2). After the calves consumed the liquid feed, their buckets were kept filled with water throughout the day and they were provided with free clean water.

Milk replacers were prepared by weighing the 125 g/L of powdered milk replacer recommended by the manufacturers and mixing them with 40–50 °C warmed water for 2.5 minutes. The calves that received milk replacer were fed with a liquid-containing milk replacer at the recommended concentration, according to the feeding schedule reported in Table 3.

Table 1 Feeding programs of experimental groups

Treatments	Alfalfa hay	Calf starter	Milk (L)/ Weeks								
			0-3 days Colostrum	4-7 days	2	3	4	5	6	7	8
Control (Whole milk, WM)	freely	freely	freely	4	4	4	4	4	4	4	4
MR 22-18	freely	freely	freely	4	4	4	4	4	4	4	4
MR 21-17	freely	freely	freely	4	4	4	4	4	4	4	4

*The amount of liquid feed specified in the program is given in two meals.

Table 2 Analyzes results of colostrum, milk, calf starter and alfalfa hay used in the experiment*

Contents	Colostrum	Milk	Calf Starter	Alfalfa Hay
Dry Material, %	77,03	87,62	87,61	89,48
Crude protein %	16,85	3,14	18,17	15,91
Crude fiber, %	0,00	0,00	14,55	28,64
Crude fat, %	3,67	3,31	3,26	1,26
Crude Ash, %	1,23	11,05	10,91	6,55
Starch	0,00	0,00	24,06	0,00

*As fed basis

Table 3 Contents of milk replacers used in the experiment*

Contents	MR 22-18	MR 21-17
Crude protein, %	22,00	21,00
Crude fat, %	18,00	17,00
Zinc, mg/kg	46,50	75,00
Iron, mg/kg	192,67	50,00
Calcium, mg/kg	0,60	1,00
Phosphorus, mg/kg	0,60	0,70
Lysine, mg/kg	2,00	1,30
Methionine, mg/kg	0,70	0,45
Copper, mg/kg	7,77	10,00
Manganese, mg/kg	102,20	30,00
Vitamin A, IU/kg	25.000,00	25.000,00
Vitamin D3, IU/kg	2.000,00	5.000,00
Vitamin E (Alpha Tocopherol Acetate), mg/kg	100,00	100,00

*As fed basis

At the end of the experiment calf starter, live weight gain, feed conversion ratio based on calf starter intake, and weaning weights of calves receiving milk replacer and calves receiving milk were recorded for further evaluation. During the experimental period the animals received alfalfa hay and starter feed ad libitum.

From day 4 to the end of the experiment, calves were kept in fiberglass calf hutches. In the calf hutches, straw bedding material was utilized, and when it became wet, litter was poured on it to keep it dry by continually supporting it. The hutch's floor was earth, and the hutch's placement was changed for each calf. The health observation records of the calves were determined during the trial by daily observations by a private veterinary health technician and veterinarian. Blood samples were taken from the jugular vein in the neck by the veterinarian, following aseptic rules, twice: after birth and after weaning. Afterwards, the samples taken into tubes without anticoagulant (10 ml, BD Vacutainer Systems, Plymouth, UK) were transported to the laboratory after being preserved in the cold chain. Then, after centrifugation (Universal 320R, Hettich, Germany) for 15 minutes at 4°C and 4000 rpm, the obtained sera were transferred to 1.5 ml Efendorf tubes with a protocol number. Efendorf tubes were stored at -20°C until analysis

The rearing cost is calculated and compared using current farm milk sale price and milk replacer prices. Experimental data was analyzed using Excel and the SPSS statistical package in Completely

Randomized Design in a 2 by 3 factorial arrangement, including gender and treatment (milk and milk substitutes).

Results and discussion

The averages, standard errors, and analysis results of the performance values of experimental groups are summarized in Table 4. The treatment effect was found to be statistically significant (P<0.05) for weaning weight, and daily weight gain while interactions between gender and treatment were not found to be statistically significant (Table 4). While the MR 22-18 group had the lowest average live weight (59.22), it was determined to be in the same group as the MR 21-17 (65.47) and whole milk-fed group (64.36).

In the analysis of variance for differences between body measurements, the effect of gender was found to be significant in the post-trial measurements, while the effect of treatment was found to be insignificant (Table 5).

Blood Parameters

The initial blood samples analysis results of the experimental groups are summarized in Table 6. Initial the blood parameters of the experimental groups were examined by gender, it was determined that the differences between the MR groups were not statistically significant except for glutamyl transferase (GGT) (Ul/l). This difference led to the detection of both MR and gender effects as significant. When the mean values of total protein and cholesterol were examined, the interaction effect was found to be significant.

The control (whole milk) and MR 21-17 males have lower total protein than females, while MR 22-18 males have higher values than female. Looking at the results of the analysis of cholesterol values from Table 6, it was determined that the mean values of the Control and MR 21-17 groups were higher in females than in males, while the opposite was in the MR 22-18 group. Therefore, the interaction effect of the mean values of total protein and cholesterol was found to be statistically significant (P<0.05).

Table 4 The performance results of experimental groups

Treatments (MR)	Gender (G)	N	Birth Weight, kg	Weaning Weight, kg	Total starter intake kg	Starter intake, g/day	ADG, g/day	FCR*
	F	8	36,90±0,78	61,84±1,46	15205,71±2324,45	271,53±41,51	445,31±25,67	0,62±0,09
Control (WM)	M	6	36,38±1,98	67,88±1,27	22000,00±3824,26	392,86±68,29	562,50±51,84	0,70±0,11
	T	14	36,68±0,89	64,36±1,31a	18036,67±2226,00	322,08±39,75	494,14±30,34a	0,65±0,07
	F	7	36,27±2,14	56,73±3,30	15151,67±3005,35	270,56±53,67	365,42±29,87	0,73±0,10
MR 22-18	M	7	39,87±2,08	61,72±2,17	14796,67±1380,49	264,23±24,65	390,18±36,66	0,69±0,07
	T	14	38,07±1,52	59,22±2,03b	14974,17±1577,58	267,39±28,17	377,80±22,85b	0,71±0,06
	F	8	36,89±1,10	63,36±1,29	19205,56±1774,28	342,96±31,68	472,68±34,18	0,75±0,08
MR 21-17	M	6	39,47±1,55	68,63±3,07	21010,00±3421,44	375,18±61,10	520,77±54,99	0,73±0,10
	T	14	37,92±0,93	65,47±1,55a	19927,33±1675,55	355,85±29,92	491,92±29,53a	0,74±0,06
Effects	MR		NS	0,01	NS	NS	0,01	NS
	Gender		NS	0,01	NS	NS	0,06	NS

F, Female; M, Male; T, Total, WW, weaning weight; ADG, average daily gain; FCR, feed conversion ratio; NS, not significant

*FCR include only starter intake not alfalfa hay and milk replacer or milk solids.

Table 5 The body measurement results of the experimental groups

Treatments (MR)	Control (WM)		MR 22-18		MR 21-17		Effects	
Gender (G)	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**G**	**MR**
N	**8**	**6**	**7**	**7**	**8**	**6**		
Initial chest girth	83,92±2,26	81,5±1,12	83,50±2,63	88,50±1,27	86,33±1,67	85,17±2,01	NS	NS
Final chest girth	96,42±1,20	94,8±1,39	93,21±0,94	91,00±1,16	89,00±0,61	94,67±2,39	0,01	NS
Initial Withers Height	77,42±0,59	75,50±0,94	76,79±1,46	79,00±0,74	75,83±0,62	79,83±1,39	NS	NS
Final withers height	84,92±1,49	87,30±0,86	88,14±1,22	84,00±1,11	85,00±1,54	85,42±1,29	0,01	NS
Body length	89,08±1,61	88,20±0,89	85,21±1,75	90,00±2,11	89,83±1,33	86,42±1,29	NS	NS
Final body length	98,25±3,14	100,20±1,49	99,07±1,05	96,6±2,36	95,17±0,71	95,50±1,44	0,01	NS

NS: not significant

Table 6 The initial metabolic profiles of the experimental groups

Treatments (MR)	Control (WM)		MR 22-18		MR 21-17		Effects		
Gender (G)	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**			
Blood parameters /N	8	6	7	7	8	6	MR	G	MR*G
Total protein (g/dl)	3,75±0,42	4,24±0,45	4,56±0,46	3,69±0,12	4,61±0,45	5,52±0,12	NS	NS	<0,05
Albumin (g/dl)	2,79±0,03	2,43±0,04	2,34±0,34	2,59±0,1	2,51±0,32	2,53±0,14	NS	NS	NS
AST (UI/l)	59±4,21	58±6,42	68,5±3,29	77,00±5,19	65,60±4,24	62,00±5,19	NS	NS	NS
Cholesterol (mg/dl)	24,00±2,12	18,00±4,38	25,00±3,31	13,00±2,3	26,80±0,52	28±1,9	NS	NS	<0,05
Glucose (mg/dl)	116,33±46,67	103,5±1,5	97,00±10,12	93,67±7,23	153,80±10,2	128,00±29,23	NS	NS	NS
GGT (UI/l)	87,88±1,88	109,5±51,35	83,33±0,11	119,33±0,84	110,00±10,25	105,00±9,84	<0,05	<0,05	NS

AST, Aspartate aminotransferase; GGT, Gama glutamyl transferase; NS, not significant

Thompson and Pauli (1981) reported that serum gamma glutamyl transferase (GGT) levels in the blood samples of calves receiving insufficient colostrum were 60 times higher than the GGT level in healthy adult cattle. It is reported that it takes about 5 weeks for this high GGT level to decrease to adult values. Another result is that the average GGT level observed in colostrum from six newly calved cows is 800 times higher than the average serum GGT level of the same cows. Therefore, it is highly likely that GGT will be high due to the simultaneous absorption of colostrum by the calves. Parish et al. (1997) reported that the GGT values 400 to 800 times higher in colostrum than in serum from adult cattle. Feitosa et al.[13] reported that GGT levels decrease as age progresses due to the renal filtration or biological degradation. Also, many researchers reported that GGT may be inferred from colostrum Ig transfer.[14,15]

The variance analysis results of final blood parameters by gender are summarized in Table 7. It is understood that the differences between the results of the analysis of blood parameters are not statistically significant ($p<0.05$), except for the GGT values.

Mohri et al.[16] reported that there were significant age-related changes ($P<0,05$) for most hematological and biochemical parameters in Holstein calves. Knowles et al.[17] report that albumin levels in calves are below the adult cattle reference range until 9 days of age. Also Zanker et al.[18] state that albumin values in 2-month-old calves are above the reference range. But Egli and Blum[19] report young and mature cattle blood parameters 28th day of birth to 84 days were similar. Göncü and Gökçe[20] reported that there was no statistically significant difference between pre-weaning and post-weaning blood parameters in Holstein calves except phosphorus. Kaygısız and Sönmez[21] reported that male calves have lower values than females. Studies comparing whole milk and MRs have reported that MR can be used successfully instead of whole milk.[22,8,9] In the current study, MR (22-18) calves consumed less starter, although it is not statistically significant, it may be among the reasons for poor performance. Especially during the weaning period, treatments affect the weaning duration and weaning weight significantly. The quality of milk replacer may also differ depending on the protein and energy sources used in its production.

Milk replacer usage cost

There have been significant developments in the formulation of milk replacer sector. It is recommended to use milk replacer in cattle farms, depending on the price and the method of milk evaluation, in all conditions. The economic analysis results of the calves in the experimental groups are summarized in Table 8.

The result of the analysis of variance showed that the differences determined in terms of costs for 1 kg of live weight gain are statistically significant ($P<0,01$) (Table 8).

Table 7 Final metabolic profiles of the groups

Treatments (MR)	Gender (G)	N	Total protein (g/dl)	Albumin (g/dl)	AST (Ul/l)	Cholesterol (mg/dl)	Glucose (mg/dl)	GGT (Ul/l)
Control (WM)	F	8	5,24±0,36	3,18±0,11	71,33±11,88	87,5±17,8	89,33±8,68	27,5±1,48
	M	6	5,21±0,4	2,95±0,19	62,43±6,84	107,86±35,14	96,29±8,69	69,43±33,33
MR 22-18	F	7	5,28±0,24	2,98±0,14	69,33±8,51	99,33±18,66	82,67±8,95	33,78±15,13
	M	7	4,65±0,33	3,01±0,13	69,22±8,61	86,78±24,35	80,33±8,15	60,67±28,87
MR 21-17	F	8	5,29±0,27	3±0,12	76,31±7,93	94,08±19,96	107,62±12,48	37,77±9,82
	M	6	5,39±0,17	2,51±0,14	68,38±5,48	89±14,03	92±9,15	50,25±26,61
Effects	MR		NS	NS	NS	NS	NS	<0,05
	G		NS	NS	NS	NS	NS	<0,05
	MR*G		<0,05	NS	NS	<0,05	NS	NS

AST, Aspartate aminotransferase; GGT, Gama glutamyl transferase

Table 8 Cost of different calf rearing methods*

Treatments (MR)	Gender (G)	Price (TL/Kg)	Cost (4 L/day)	Starter intake, (g/day)	Daily Gain, (g/day)	Total cost (TL/day)	Cost per kg Live weight gain (TL/kg)
Gender (G)	Female	12	48	271,53	445,31	50,17	115,21
	Male	12	48	392,86	562,50	51,14	93,86
MR 22-18	Female	64,48	32,24	270,56	365,42	34,40	96,85
	Male	64,48	32,24	264,23	390,18	34,35	92,14
MR 21-17	Female	60,68	30,34	342,96	472,68	33,08	72,96
	Male	60,68	30,34	375,18	520,77	33,34	70,78a
Effects						0,000	0,000

*Milk and replacer prices dated 15.06.22023 were used in the calculations. Milk: 12 TL/kg, calf starter: 8 TL/kg, MR 22-18: 64.48 TL/kg, MR 21-17: 60.68 TL/kg

While the cost of 1 kg body weight gain was the lowest in the MR 21-17 (70,78a), the MR 22-18 (94,49b) and control groups (106,31b) costs were similar. It should be noted that the economic efficiency of milk replacers depends on the growth performance to be achieved, milk and milk replacer prices. Tuncer and Coşkun[7] showed that calves fed with milk replacers have similar results to calves fed with limited full-fat milk. Kaygısız and Sönmez[21] report that although the cost of feeding with MR in the period until weaning is lower than feeding with milk, the unit cost is higher in terms of total live weight gain. Kaya et al.[23] reported that there was no difference between the groups consuming normal and sour milk in terms of dry matter consumption, Yanar et al.[24] Bayram et al.[25] reported that calves consuming normal and sour milk did not adversely affect their ability to benefit from feed. Milk replacer, which is used by around 60% of America, is the most used and economical feed type after waste milk by large farms.[1] When the two groups were compared in terms of feeding costs,[9] reported that the feeding costs (including roughage and concentrate) of calves receiving milk replacer were significantly lower.

Calf diarrhea

Cases of diarrhea in experimental animals were also recorded in the present study. All the calves in this trial were housed in the calf hutches, and the establishment was under constant veterinary control in terms of hygienic conditions, care, and management. In the study, in terms of the number of calves with diarrhea, short-term loose stools were detected at the beginning of the trial in 3 calves in WM, MR 22-18, and MR 21-17. The necessary intervention by the veterinarian was made immediately.[26–28]

Conclusion

The results showed that MR 21-17 resulted in similar calf performance with whole milk, but MR 22-18 had lower growth performance compared to milk and MR 21-17. MR 21-17 has better performances than MR 22-18 although MR 22-18 has higher protein and fat content than MR 21-17. Additionally, MR 21-17 has a lower feeding cost compared to whole milk and MR 22-18. The performance results revealed that milk replacer ingredient quality is one of the main issues for effective calf rearing.

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Conflicts of Interest

Author declares there is no conflict of interest in publishing the article.

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