Effect of organic acid salts supplementation on milk production, milk composition and blood parameters in early lactation dairy cows

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SUMMARY

This study aims to evaluate the effects of organic acid salts supplementation on early-lactation Montbéliarde (MO) and Normande (NO) dairy cows. Seventy cows (36 MO, 34 NO) were allocated to two groups (n = 35 each). The supplemented group (OA) received 50 g/cow/day of calcium and sodium malate and propionate salts from calving to 65 days postpartum, while the control group (CON) received no additives. Daily milk production was recorded for each cow, and milk composition (protein, fat, lactose) was analyzed on Days 7, 35, and 65 postpartum. Blood samples were collected on Days 7, 14, and 21 postpartum to determine biochemical parameters. Organic acid salts supplementation significantly increased milk yield and improved milk fat, protein, and lactose yields and concentrations. A significant interaction between supplementation and breed was observed for both milk yield and lactose. Significant effects were also found for blood glucose, triglycerides, albumin, total protein, and calcium concentrations. Higher blood glucose levels suggest enhanced energy status, potentially reducing the risk of hepatic steatosis by lowering triglyceride and non-esterified fatty acid accumulation. Increased plasma protein and albumin levels indicate improved liver function and protein synthesis, supporting milk production. Higher blood calcium concentrations suggest better metabolic adaptation to lactational demands. Overall, organic acid salts supplementation may help maintain health and productivity during early lactation, reducing production losses and improving dairy farm profitability.

KEY WORDS

Organic acid salts; Early lactation; Dairy cows; Milk production; Blood biochemical parameters.

INTRODUCTION

The transition period, which encompasses the three weeks pre- and post-calving, is a critical physiological stage for dairy cows and is associated with an increased risk of infectious diseases and metabolic disorders [1]. During the prepartum phase, feed intake declines while nutrient requirements increase to support fetal development and prepare for lactation. After calving, the onset of lactation and the rapid rise in milk production substantially increase glucose demands for lactose synthesis, precisely when feed intake has not yet reached its peak. This imbalance in energy demands leads to a negative energy balance (NEB). The resulting energy deficit triggers the mobilization of body reserves, primarily from adipose tissue, causing elevated plasma concentrations of non-esterified fatty acids (NEFAs). These NEFAs are subsequently oxidized by the liver and other tissues for energy. However, excessive mobilization can result in hepatic triglyceride accumulation and elevated blood levels of lipid metabolites, contributing to metabolic disorders such as ketosis and fatty liver syndrome [1].

To minimize metabolic disorders, several strategies have been proposed, including the incorporation of dietary additives during the prepartum and postpartum periods. In this context, organic acid supplementation improves nutrient utilization in the gastrointestinal tract of dairy cows. Commonly used as feed additives, these acids are primarily natural compounds involved in cellular metabolism, making them naturally occurring and low in toxicity [2]. Many organic acids are also used in the form of sodium, potassium, or calcium salts, which reduce odor, facilitate handling during feed preparation, decrease corrosiveness, and improve water solubility compared to free acids [3]. Among these acidifiers, propionate and malate, along with their salts, play important roles in the metabolism and health of dairy cows. Propionate acts as an important gluconeogenic precursor, increasing glucose concentrations and enhancing metabolic intermediates in the liver [4]. Its supplementation has been associated with elevated blood glucose levels and reduced concentrations of blood beta-hydroxybutyrate (BHB) [5]. Calcium propionate supplementation may help mitigate negative

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energy balance (NEB) and hypocalcemia in periparturient cows, while also inhibiting mold growth in feed [6].
Malate stimulates lactate utilization by *Selenomonas ruminantium*, a predominant ruminal bacterium, leading to increased propionate production and reduced lactate concentrations [7]. In vitro studies have demonstrated that malate supplementation increases pH and propionate production while decreasing lactate concentrations in rumen fermentations [8]. Building on these findings, dietary supplementation with organic acids is expected to positively influence the metabolic status and overall performance of dairy cows. Therefore, this study aims to evaluate the effects of supplementing dairy cows in early lactation with a mixture of organic acids and their salts, primarily malate and propionate salts, on milk yield, milk composition, and plasma metabolite concentrations in Montbéliarde and Normande cows.

MATERIAL AND METHODS

Experimental design and animal diet

The study was conducted from January 2021 to March 2021 on a privately owned dairy farm in the province of Setif, northeastern Algeria, located at 35°56’16” N and 5°32’11” E, at an altitude of 913 m above sea level (Figure 1). A total of seventy pregnant dairy cows, including 36 Montbéliarde (MO) and 34 Normande (NO), with an average milk yield of 25.09 ± 7.02 kg/day and an average body weight of 741 ± 89.3 kg, were selected. At dry-off, 60 ± 3 days prior to the expected calving date, all cows were housed in tie-stalls under uniform management conditions and fed the same diet. Following calving, during the experimental period from Day 1 to Day 65 postpartum, the cows were randomly divided into two groups of 35 cows each (18 MO and 17 NO). The control group (CON) received a total mixed ration, as detailed in Table 1, while the supplemented group (OA) was provided the same ration with the addition of 50 g/cow/day of organic acid salts. The supplement, Rumitec 2.0®, was manually and uniformly mixed into the concentrate. This supplement consists of the sodium and calcium salts of malic and propionic acids. Each cow received its individual ration three times daily at 7:00, 12:00, and 17:00 in equal amounts.

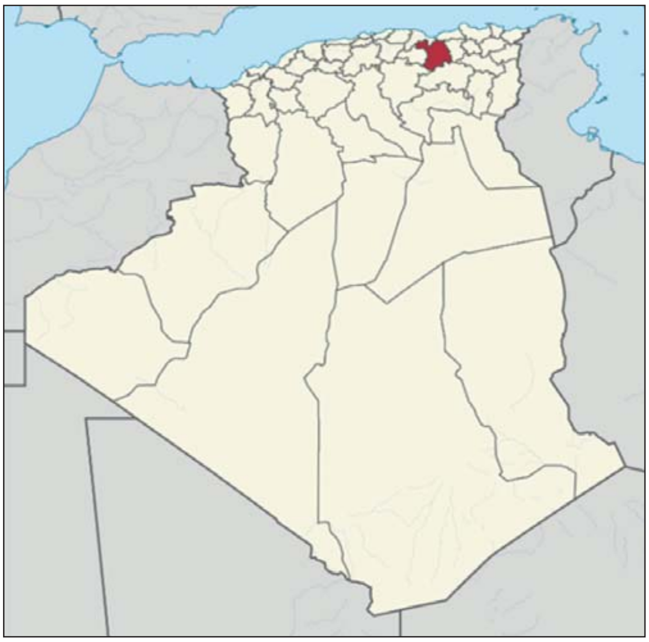

Figure 1 - Geolocation of the Setif province in Algeria.

Feed samples and chemical analysis

At the beginning of the experiment, samples of forages (alfalfa hay and maize silage) and concentrate components of the cows’ ration were collected for analysis. The samples were dried in a forced-air oven at 60°C for 48 h and then ground to pass through a 1-mm screen for subsequent nutrient analysis. The chemical composition was determined according to the methods described by the Association of Official Analytical Chemists [9]: dry matter (DM; method 930.15), ash (method 942.05), crude protein (CP; method 984.13), crude fiber (CF; method 978.10), and ether extract (EE; method 920.39). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents of the samples were determined according to the method of Van Soest et al. [10].

Milk samples and composition analysis

Individual milk yield (kg/day) was recorded daily for the first 75 days postpartum to determine the average daily milk production for each group. The cows were milked twice daily, at 12-hour intervals (4 am and 4 pm). Milk samples from both milkings were collected on Days 7, 35, and 65 postpartum, stored in sterilized 50 mL plastic bottles at 4°C, and analyzed in the farm laboratory within 4 hours for physicochemical analysis. Milk fat, protein, and lactose yields (g/day) and percentages (%) were calculated using a Lacto-scan Milk Analyzer (Milkotronic LTD, Europe).

Blood samples and analysis

Blood samples were collected on Days 7, 14, and 21 postpartum from each cow using a bovine needle (TERUMO; 18G) and a heparinized 7 mL tube containing lithium heparin. Sampling was performed by puncturing the coccygeal vein between 7 and 10 am. The samples were then centrifuged at 3000 rpm for 15 minutes, and the plasma was collected in 2 mL tubes and stored at −10°C until analysis. Biochemical plasma parameters were analyzed using commercial kits (Spinreact SA, Spain). Plasma concentrations of glucose (GLU), total triglycerides (TRG),

Table 1 - Ingredients and nutrient composition of the basal diet in the early lactation dairy cows.

Items	Value
Ingredient, % of DM	
Alfalfa hay	11.17
Corn silage	14.29
Concentrate mixture	74.54
Chemical composition	
DM	88.51
NDF	51.06
ADF	18
CP	22.61
EE	3.17
Ash	2.71

albumin (ALB), total protein (TP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), magnesium (Mg), phosphorus (P), and calcium (Ca) were determined using a quantitative colorimetric enzymatic method with an automatic analyzer (Techni-con® equipment, model RAXT).

Statistical analysis

Data were analyzed using a mixed linear model with repeated measures, employing the Proc Mixed procedure of SAS® software (version 9.3). This analysis accounted for both fixed and random effects. The model included the fixed effects of treatment (CON and OA), breed (MO and NO), and measurement day (Days 15, 30, 45, 60, and 75 postpartum for the milk production variable PL; Days 7, 35, and 65 postpartum for milk composition variables; and Days 7, 14, and 21 postpartum for plasma parameters), as well as the interaction between treatment (TRT) and breed (BR). The random effect of subject was included to account for repeated measures. The statistical model is expressed by the following formula:

$$Y_{ijkl} = \mu + T_i + R_j + D_k + (T \times R)_{ij} + S_l + \varepsilon_{ijkl} \ (1)$$

where, Y_{ijkl} is the dependent variable, μ is the overall mean, T_i is the fixed effect of treatment *i*, R_j is the fixed effect of breed *j*, D_k is the fixed effect of day *k*, $(T \times R)_{ij}$ is the interaction between treatment and breed, S_l represents the random effect of subject $_l$, and ε_{ijkl} is the residual error.

Differences between least squares means for the various dependent variables were compared and considered statistically significant at $P < 0.05$, while trends were discussed for $0.05 \leq P < 0.10$.

RESULTS

Milk yield and milk composition

Tables 2 and 3 present the effects of organic acid salts supplementation (OA), breed (Montbéliarde and Normande), and their interaction (OA × Breed) on daily milk yield (kg/day) and milk components, including fat, protein, and lactose, as well as the changes in these parameters throughout the postpartum period. Organic acid salts supplementation had a significant impact on milk yield ($P < 0.05$). Over the first 75 days postpartum, cows in the OA group produced 1.89 kg/day more milk than those in the CON group. Milk yield also varied significantly throughout the postpartum period ($P = 0.0174$). The interaction between organic acid supplementation and breed was statistically significant ($P = 0.0016$). While supplemented Normande cows showed a marked increase in milk yield (+13.9 %) compared to the control Normande group, Montbéliarde cows exhibited a more modest response in the OA group compared to their control group, with only a marginal increase of 0.6% (Table 2).

Supplementation with organic acid salts also had a statistically significant effect on milk composition, including fat and protein content (g/day), protein percentage, and lactose levels ($P < 0.05$) (Table 3). Cows in the OA group produced a higher quantity of milk fat compared to the control group. Additionally, Montbéliarde cows had higher milk fat production than Normande cows ($P = 0.0268$). Protein content increased steadily during the postpartum period, rising by 20.6% from Day 7 to Day 65 ($P = 0.0010$). Protein production was also enhanced by organic acid salts supplementation ($P = 0.0063$). Furthermore, supplemented cows showed higher milk protein (+5.4%, $P = 0.0281$) and milk fat (+5.5%, $P = 0.0172$) percentages compared to non-supplemented cows. Protein levels varied significantly overall ($P = 0.0139$) during the postpartum period (Day 1 to Day 65), with a notable 8.5% increase observed between Day 7 and Day 65, reaching 3.32% on Day 65.

Finally, OA supplementation had a highly significant effect on lactose levels ($P < 0.0001$), with higher averages recorded in the OA group (4.54%) compared to the CON group (4.30%). Lactose levels also increased significantly over the study period ($P < 0.0001$), rising from 4.25% on Day 7 to 4.57% on Day 65. The results show a significant interaction effect ($P < 0.001$) between breed and treatment on milk lactose content. In both breeds, the supplemented group exhibited higher lactose levels than the control, with the increase more pronounced in Normande cows, leading to the highest overall lactose content under OA supplementation.

Blood metabolic profile

The results in Table 4 show the effects of dietary supplementation with organic acid salts (OA), breed, their interaction, and sampling period on the biochemical parameters of dairy cows during lactation from Day 7 to Day 21. Supplementation with sodium and calcium salts of malate and propionate significantly affected the concentrations of several blood biochemical parameters (Table 4). Specifically, supplementation increased blood glucose levels by 8% ($P < 0.0001$) compared to the control group. Significant effects of supplementation were also observed for plasma concentrations of triglycerides ($P = 0.0028$), albumin ($P = 0.0039$), total proteins ($P = 0.0326$), and calcium ($P = 0.017$). Supplemented cows had lower triglyceride levels and higher concentrations of total proteins (+3.6%), albumin (+5%), and calcium (+3%) than non-supplemented cows. The organic acid treatment had no effect ($P > 0.05$) on plasma concentrations of ALT, AST, magnesium, or phosphorus. Plasma concentrations of glucose and triglycerides varied significantly over time. Both metabolites showed a moderate increase between Days 7 and 21 postpartum by 12% for glucose ($P = 0.0002$) and 23% for triglycerides ($P < 0.001$). Regarding breed effects, Montbéliarde and Normande cows showed similar levels of glucose, triglycerides, and total proteins ($P > 0.05$). However, ALT concentrations differed significantly between the two breeds ($P = 0.0197$). In addition, a significant interaction between OA treatment and breed was observed for total protein levels ($P = 0.0196$), with supplemented Normande cows exhibiting higher total protein concentrations compared to control Normande cows.

DISCUSSION

Milk yield and milk composition

In the present study, the inclusion of organic acid salts (50 g per cow per day) in the diets of dairy cows resulted in a significant increase in milk production. This improvement may be attributed to the multifactorial effects of specific components of the organic acid salts on nutrient digestion and utilization. These findings are consistent with those of Ali et al. [11], who reported beneficial effets effects of malate salt supplementation on dairy performance, particularly an increase in milk yield during early lactation. Similarly, during the same

Table 2 - Effects of calcium and sodium salts of malate and propionate supplementation on milk yield during early lactation in Montbéliarde and Normande dairy cows.

	Treatment (TRT)		Breed (BR)		Time (TM)					TRT *BR					*P*-value			
										CON		OA						
Item	CON	OA	MO	NO	D15	D30	D45	D60	D75	MO	NO	MO	NO	SEM	TRT	BR	TM	TRT*BR
Milk yield (kg/day)	27.20	29.09	28.50	27.80	26.71^{a}	27.67^{ab}	28.02^{ab}	28.70^{ab}	29.61^{b}	28.42	25.99	28.58	29.60	0.34	0.0006	0.0104	0.0174	0.0016

CON - control group; OA - organic acid salt group; SEM - standard error of the mean; $^{a, b}$ - means within rows with different superscripts are significantly different at $P < 0.05$.

postpartum period (63 days), Wang et al. [12] observed an increase of 1.82 kg/day in milk production in cows supplemented with 210 g/day of malic acid ($P = 0.04$).

Furthermore, Zhang et al. [13] recorded a significant increase exceeding 3 kg/day in milk yield in cows supplemented with 300 g/day of calcium propionate over a shorter period, from Day 0 to Day 35 postpartum. Supplementation with malate stimulates propionate production by the bacterium *Selenomonas ruminantium*, promoting the conversion of lactate to propionate via the succinate-propionate pathway [7]. Propionate is absorbed through the rumen wall and transported to the liver, where it serves as a precursor for gluconeogenesis. Glucose, in turn, is the primary precursor for lactose synthesis, the main osmoregulatory factor in milk production. Adequate glucose availability supports milk yield and enhances immunity in dairy cows during the transition period [13].

Regarding milk composition, the present study revealed a significant increase in protein yield in the group treated with organic acid salts. This effect may be related to elevated propionic acid production, which acts as a glucose precursor and allows for the sparing of amino acids for milk protein synthesis.

An increase in milk fat yield was also observed in cows supplemented with sodium and calcium propionate and malate salts. These findings are consistent with those of Karim et al. [14], who found that adding 100 g/day of calcium propionate increased both milk production and fat content. Wukadinovich and Ossow [15] reported that sodium propionate supplementation during the postpartum period increased milk fat yield in primiparous cows. In addition to its effects on protein and fat, organic acid salt supplementation had a highly significant effect on milk lactose percentage in supplemented cows. Supporting these results, Martins et al. [16] reported that calcium propionate supplementation significantly increased lactose levels, suggesting that propionate serves as an energy source by being converted into glucose through hepatic gluconeogenesis. The availability of glucose in the mammary gland is essential for lactose synthesis, which is a major component of milk and a key factor in mammary osmoregulation [17].

In contrast, several studies have reported contradictory results. McNamara and Valdez [18] found that calcium propionate supplementation (125 g/day) tended to reduce milk fat percentage, lactose, and protein. Ebtehag et al. [19] also observed a significant decrease in milk fat and lactose content in cows fed rations containing malic acid and malate salts compared to the control group. However, Sniffen et al. [20] reported no effect of malic acid supplementation on milk fat, true protein, or lactose content. These discrepancies in milk production and composition outcomes may reflect differences in supplementation levels, basal diets, feeding regimes, and body condition [13].

In this study, organic acid salts supplementation showed a significant interaction with breed, as reflected by a particularly pronounced effect on milk yield in supplemented Normande cows. By contrast, Montbéliarde cows, which naturally have higher milk production potential than Normande cows [21], showed lower sensitivity to the supplement, likely because their inherent production capacity could mask the effects of OA supplementation. These differences may be due to genetic or physiological variations between the two breeds.

The impact of breed in this study was limited to significant differences in milk yield and fat content. Montbéliarde cows are known for their high milk fat content and yield, partly due to the high frequency of the A allele of the *K232A* polymorphism in the *DGAT1* gene, which plays a key role in fat synthesis [22]. Indeed, milk fat content is often more genetically influenced than other components, as it is directly linked to energy storage pathways, which vary considerably across breeds depending on natural adaptation and selective breeding for specific production traits. In contrast, protein and lactose concentrations tend to be more uniformly regulated across breeds [23].

Blood metabolic profile

The determination of biochemical parameters in dairy cows is essential for predicting potential metabolic disorders dur-

Table 3 - Effects of calcium and sodium salts of malate and propionate supplementation on milk fat, protein, and lactose concentrations during the first 65 days postpartum in Montbéliarde and Normande cows.

	Treatment (TRT)		Breed (BR)		Time (TM)			TRT *BR					*P* value			
									CON	OA						
Item	CON	OA	MO	NO	D7	D35	D65	MO	NO	MO	NO	SEM	TRT	BR	TM	TRT*BR
Fat yield (g/day)	998.72	1113.33	1075.46	1036.59	1028.61	1047.30	1092.17	1057.61	939.83	1093.32	1133.35	24.83	0.0086	0.0268	0.5080	0.0646
Protein yield (g/day)	867.15	969.70	930.45	906.40	831.57^{a}	920.39^{ab}	1003.31^{b}	913.51	820.80	947.39	992.00	20.97	0.0063	0.4379	0.0010	0.0669
Fat %	3.61	3.81	3.74	3.69	3.80	3.69	3.65	3.65	3.57	3.82	3.81	0.05	0.0172	0.2711	0.3090	0.6726
Protein %	3.12	3.29	3.20	3.21	3.06^{a}	3.23^{ab}	3.32^{b}	3.14	3.10	3.25	3.32	0.04	0.0281	0.8125	0.0139	0.4752
Lactose %	4.30	4.54	4.44	4.40	4.25^{a}	4.44^{b}	4.57^{c}	4.40	4.20	4.48	4.60	0.02	<0.0001	0.3886	<0.0001	0.0002

CON - control group; OA - organic acid salt group; SEM - standard error of the mean; $^{a, b, c}$ - means within rows with different superscripts are significantly different at $P < 0.05$.

Table 4 - Changes in blood glucose, protein, triglycerides, and mineral concentrations following calcium and sodium malate and propionate salts supplementation in Montbéliarde and Normande cows during the first 21 days postpartum.

	Treatment (TRT)		Breed (BR)		Time (TM)			TRT *BR					*P* value			
								CON		OA						
Item	CON	OA	MO	NO	D7	D14	D21	MO	NO	MO	NO	SEM	TRT	BR	TM	TRT*BR
GLU (g/L)	0.51	0.55	0.53	0.53	0.5[a]	0.53[b]	0.56[c]	0.52	0.49	0.54	0.56	0.006	<0.0001	0.053	0.0002	0.11
TRG (g/l)	0.20	0.18	0.19	0.19	0.17[a]	0.18[a]	0.21[b]	0.20	0.20	0.17	0.18	0.004	0.0028	0.78	<0.0001	0.35
ALB (g/l)	32.48	34.24	33.90	32.83	32.42	33.74	33.92	32.92	32.04	34.87	33.61	0.34	0.0039	0.29	0.10	0.75
TP (g/l)	69.70	72.19	72.95	68.94	70.31	70.79	71.74	73.07	66.33	72.83	71.55	0.68	0.0326	0.20	0.62	0.0196
ALT (UI/L)	33.08	33.78	33.86	33.00	32.43	33.36	34.50	32.87	33.29	34.85	32.71	0.40	0.32	0.0197	0.0595	0.0691
AST (IU/l)	51.64	50.45	50.69	51.40	49.91	50.94	52.28	50.44	50.45	50.93	52.35	0.51	0.18	0.08	0.10	0.42
Mg (g/l)	25.02	25.50	25.39	25.12	24.64	25.55	25.60	25.47	25.53	25.31	24.72	0.30	0.10	0.26	0.26	0.54
P (g/l)	66.73	66.54	67.34	65.93	66.81	66.34	66.75	66.68	66.77	67.99	65.09	0.86	0.90	0.98	0.96	0.32
Ca (g/l)	78.95	81.07	80.07	78.95	79.13	79.83	81.07	78.92	78.98	81.22	80.91	0.49	0.0172	0.71	0.18	0.83

CON - control group; OA - organic acid salt group; SEM - standard error of the mean; [a, b, c] - means within rows with different superscripts are significantly different at $P < 0.05$.

ing early lactation. In this study, supplementation with malate and propionate salts significantly increased blood glucose levels in early-lactation cows. Consistent with these findings, Wang et al. [12] reported a linear increase in glucose concentrations in cows supplemented with malate between Days 7 and 21 of lactation, attributing this rise to enhanced ruminal propionate production. Patel et al. [24] also observed increased glucose concentrations in lactating cows supplemented with malic acid. After ruminal absorption, propionate is transported to the liver, where it acts as a gluconeogenic precursor. Between Days 1 and 21 postpartum, hepatic conversion of propionate to glucose can increase by 85 to 126% compared to pre-calving values [25].

Liu et al. [26] found that adding 100, 200, or 300 g/day of calcium propionate to the total mixed ration during the first 63 days of lactation improved energy status, resulting in higher blood glucose concentrations in multiparous Holstein cows. In early lactation, negative energy balance elevates non-esterified fatty acids (NEFAs) concentrations in the blood due to increased lipid mobilization from adipose tissue. When the liver's capacity to metabolize these NEFAs is exceeded, triglyceride (TG) accumulation and ketone body production may occur, increasing the risk of ketosis, fatty liver, and other serious metabolic disorders [1].

In this study, supplementation with malate and propionate salts reduced triglyceride levels in treated cows. As a major gluconeogenic precursor, propionate stimulates glucose production, thereby improving energy balance and reducing the need for excessive mobilization of body fat and NEFAs release into the bloodstream [5]. This, in turn, lowers hepatic NEFAs accumulation and reduces the risk of hepatic steatosis [1]. Additionally, malate-an intermediate in the Krebs cycle-facilitates fatty acid oxidation in the liver. By optimizing this process, malate may help limit triglyceride deposition in hepatocytes, reducing cellular damage and improving metabolic health in lactating cows [27].

The results indicate that supplementation with malate and propionate salts increased plasma total protein and albumin levels during the first 21 days postpartum. These findings are supported by Ebtehag et al. [19], who also observed elevated plasma protein and albumin concentrations in cows supplemented with malate salts. The liver plays a key role in synthesizing plasma proteins, including albumin, making albumin a reliable indicator of hepatic function [19]. Higher albumin concentrations reflect improved protein synthesis and storage, while lower total protein and albumin may indicate hepatic dysfunction [28]. Maintaining optimal liver function is essential for sustaining normal production performance during early lactation.

Hepatic enzyme levels are commonly measured as indicators of liver function [29], and elevated values may indicate hepatocellular damage and impaired liver function [13]. In the present study, malate and propionate supplementation did not affect ALT or AST levels. Zhang et al. [13] reported a significant decrease in ALT in cows supplemented with 350 g/day of calcium propionate and a significant increase in AST in cows given 500 g/day from calving to Day 35 of early lactation.

During early lactation, dietary calcium absorption, bone calcium mobilization, and renal calcium reabsorption often fail to meet the sharp rise in calcium demand for colostrum and milk production. As a result, many cows experience some degree of hypocalcemia [27]. Goff et al. [25] demonstrated that administering calcium propionate at calving and 12 hours postpartum effectively reduces the incidence of subclinical hypocalcemia. The present findings showed an increase in plasma calcium levels in the group supplemented with organic acid salts. Similarly, Ravi et al. [30] reported that calcium propionate supplementation increased serum calcium levels, with a dose-dependent trend during early lactation. In contrast, Patel et al. [24] found that supplementation with malic acid did not influence blood concentrations of total protein, albumin, globulin, urea, creatinine, cholesterol, ALT, or AST.

CONCLUSION

Supplementation with calcium and sodium salts of malate and propionate in early-lactation Montbéliarde and Normande dairy cows improved milk yield, milk composition, and key metabolic parameters. The observed increase in blood glucose levels suggests enhanced energy status, while higher plasma protein, albumin, and calcium concentrations indicate improved liver function and better metabolic adaptation to lactation. The response varied by breed, highlighting the relevance of genetic and physiological differences when designing nutritional strategies.

These findings underscore the potential of organic acid salts to support dairy cow health and productivity, reduce production losses, and enhance farm profitability during early lactation. However, this study was limited to a short-term period (65 days postpartum), and long-term outcomes were not assessed. Further research should investigate the sustained effects on milk quality, physiological status, and the factors influencing the efficacy of supplementation in dairy farming.

Ethical approval

The research was approved by the scientific council of the Higher National Veterinary School of Algiers, (N° 266/ D.P.G.R/2018).

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Conflict of interest

The authors declared that there is no conflict of interest.

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