



## Effect of different feeding strategies on lactation and reproductive performances of dairy cows in the semi-arid region

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### ABSTRACT

Dairy farming in Algeria relies on a simple diet composed of dry forage, corn silage, and concentrates in varying proportions. The present study aimed to evaluate and compare lactation and reproduction performances of dairy cows fed according to three different feeding rations: a total mixed ration (TMR G1), TMR supplemented with alfalfa pellets (G2), and a conventional feed (G3) where forage and concentrates are distributed separately. Eighteen primiparous Montbéliarde cows, with an average initial body weight of  $511 \pm 66.98$  kg were monitored over two lactations. Cows received G3 ration had the highest average live weight and body reserves ( $554 \pm 46.72$  kg) compared to G1 ( $505 \pm 96.55$  kg) and G2 ( $462 \pm 38.73$  kg) ( $p < 0.05$ ). The milk performances had an average of  $6439.5 \pm 743.02$ ,  $6065 \pm 647.04$  and  $6347 \pm 886.78$  kg/year for the three rations, respectively. Lactation persistence was 92.7%, 93.2%, and 81.7% for the three groups, respectively. Milk fat and protein contents were  $33.41 \pm 2.26$ ,  $32.79 \pm 2.51$  and  $35.35 \pm 2.09$  g/kg;  $30.73 \pm 0.72$ ,  $29.96 \pm 0.84$  and  $30.58 \pm 0.93$  g/kg, respectively. The three feeding rations led to a considerable variation in reproductive performances, with calving intervals of  $370 \pm 24.70$ ;  $360 \pm 71.01$ , and  $404 \pm 40.62$  days, respectively. Cows received G2 ration had the highest first insemination success rate (83.33%). These results confirm the effectiveness of TMR feeding as a promising strategy to support overall performance of dairy herds.

**Keywords:** Dairy cow, Feeding, Milk performance, Total mixed rations

The dairy industry in Algeria is currently facing a critical situation, marked by inadequate local production, low rates of collection, and escalating prices of raw materials utilized in feed production. Additionally, the substantial demand for milk, averaging 150 liters per person annually, contributes to a national consumption of approximately 6 billion liters (FAO, 2015). In Algeria, the average milk yield per cow per lactation stands at approximately 3600 kg, falling short of the genetic potential observed in imported dairy heifers, which is estimated between 5000 and 6000 kilograms per lactation in their countries of origin (Bellil and Boukrif, 2021).

The suboptimal productivity observed in dairy farms in Algeria results from a combination of factors, including inadequate and substandard feeding practices, ineffective livestock management, and insufficient technical skills (Djermoun and Benziouche, 2017; Makhoulf and Montaigne, 2017). Additionally, the region's climatic conditions, particularly the frequent occurrence of dry seasons, contribute to water resource scarcity, thereby

impeding the cultivation of fodder crops. The feeding systems are plagued by persistent shortage of forage, low-quality staple foods, and imbalanced ration. Furthermore, the reliance on external resources within the farm can severely compromise the economic viability of dairy operations (Gharbi *et al.* 2007).

Feeding livestock animals poses a complex and persistent challenge for farmers. They are confronted with the need to reconcile various concerns, including meeting the nutritional needs for maintenance and production of animals, preserving product quality, optimizing feeding costs, while minimizing waste and pollution (Akintan *et al.* 2024).

The aim of this study is to introduce and refine innovative feeding methods, particularly by implementing nutritionally balanced and economically feasible total mixed rations. This approach seeks to enhance and stabilize milk production in both quantity and quality while also preserving the productive longevity of cows.

### MATERIALS AND METHODS

*Experimental animals:* The study was conducted over a period of two years (2022-2023) at the COOPSEL farm school, located in the semi-arid region of Sétif. Eighteen primiparous Montbéliarde cows, with an average body

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weight of  $511 \pm 66.9$  kg at the beginning of the experiment, were divided into three groups of six animals each ( $n = 6$ ) based on their age, body weight, calving date, and productivity level of their mothers. The average age at first calving was  $30.56 \pm 4.60$  months. The average body condition scores (BCS) were  $2.79 \pm 0.44$ . The average calf weight at birth was  $37.8 \pm 5.2$  kg for all groups. No significant differences were observed between the groups for these initial parameters ( $p > 0.05$ )

The experiment included two successive lactations, and the rearing conditions were the same for each group. The cows were housed in a straw-bedded loose housing barn with unlimited access to drinking water and natural ventilation and lighting.

The farming was practiced in a soilless environment. The air temperature in the experimental facility ranged from  $1^{\circ}\text{C}$  to  $26^{\circ}\text{C}$ , with an average of  $13.5^{\circ}\text{C}$ .

The three groups received different feed rations to study and compare the effect of these rations on the zootechnical performance of the cows. Each group received the same assigned diet throughout the experiment. A transition period of 15 days was implemented at the beginning of the experiment to allow cows to adapt gradually to the experimental rations, minimize digestive disturbances, and ensure stable feed intake before data collection. Feeds were distributed four times a day (7 a.m., 11 a.m., 2 p.m., 6 p.m.).

*Diet composition:* Feed rations are formulated in accordance with the dietary standards for dairy cows, taking into account productivity and physiological state (Tables 1; 2).

*Experimental measurements:* Feed intake was calculated weekly by measuring the difference of weight of given and refused feeds. The cows' body weight was

Table 1. Diet composition

Raw Materials	Rations		
	Mash 1	Mash 2	Concentrate
	%		
Corn	31.35	31.35	29
Wheat bran	20	23	45
Soybean meal	18	18	18
Alfalfa hay	8	13	0
Alfalfa pellets	7	0	0
Wheat Straw	4	4	0
Molasses	8	7	5
Mineral and vitamin premix	1	1	1
Sodium bicarbonate	1.2	1.2	1.2
Calcium carbonate	0.5	0.5	0.5
Urea	0.7	0.7	0
Salt	0.25	0.25	0.3

Table 2. Daily distribution and nutritional characteristics of the three rations given to different groups

Composition / Parameters	G1	G2	G3
Daily distribution (kg/cow, as feed)			
Mash 1	10	0	0
Mash 2	0	10	0
Concentrate	0	0	9
Corn silage	18	18	18
Alfalfa hay	4.5	4.5	4
Wheat straw	3	3	3
Nutritional characteristics			
UFL	19.2	19.2	18.0
PDI (g/day)	1858.5	1850.8	1698.6
PDI/UFL	96.70	96.25	94.21
NDF (% DM)	42.55	42.87	42.92
ADF (% DM)	22.90	22.80	21.40
Starch (% DM)	11.43	11.62	12.56

UFL: Net energy for lactation; PDI: Digestible protein in the intestine; NDF: Neutral detergent fiber; ADF: Acid detergent fiber

evaluated on a monthly basis prior to feeding, and the body condition scoring (BCS) was conducted using standardized scoring charts tailored specifically for Montbéliarde cows (Vasseur *et al.* 2013). The quantities of milk produced were evaluated every two weeks. The maximum milk production ( $MP_{Max}$ ) was determined by identifying the highest value among the daily averages calculated over the various weeks of lactation. The milk production at 305 days ( $MP_{305}$ ) was computed using the cumulative milk production data collected throughout the monitoring period. Fecal consistency and presence of undigested fecal particles were assessed based on the grid outlined by Zaaijer and Noordhuizen (2003). Regarding reproductive performance, observations included the date of the last insemination, calving date, as well as details regarding calf sex and weight, results of consecutive pregnancy diagnoses, and calving intervals.

*Milk analysis:* During the initial and subsequent lactations, 250 ml milk samples were collected from each cow immediately following the morning milking. These samples were stored in bottles and placed in a portable insulated cooler for physicochemical analysis. Three analyses were conducted simultaneously on each sample, and the findings were averaged. Milk samples were analyzed monthly using a spectrometric milk analyzer (LACTOSCAN Ultrasonic Milk Analyzer). The measurements encompassed pH, density, lactose, fat content, protein content, total solids, and defatted dry extract concentrations.

*Data Processing:* The collected data were recorded and organized in an Excel spreadsheet. Depending on the type of data collected during the experiment and the objective of the processing, means and standard deviations were

Table 3. Live weight and body condition score at calving

Stage	G1	G2	G3
LW- 1 <sup>st</sup> calving	505 ± 96.55 <sub>a</sub> b	462 ± 38.73 <sub>a</sub>	554 ± 46.72 <sub>b</sub>
LW-2 <sup>nd</sup> calving	674 ± 86.21 <sub>a</sub>	674.5 ± 96.40 <sub>a</sub>	677.5 ± 68.69 <sub>a</sub>
BCS-1 <sup>st</sup> calving	3.16 ± 0.12 <sub>a</sub>	2.95 ± 0.55 <sub>a</sub>	3.45 ± 0.45 <sub>a</sub>
BCS-2 <sup>nd</sup> calving	3.17 ± 0.46 <sub>a</sub>	3.17 ± 0.43 <sub>a</sub>	3.46 ± 0.84 <sub>a</sub>
BCS -Dry cow	3.5 ± 0.41 <sub>a</sub>	3.38 ± 0.30 <sub>a</sub>	3.37 ± 0.85 <sub>a</sub>

<sup>abc</sup> significant difference on the values of the same line ( $p < 0.05$ ). LW: Live weight ; BCS: Body condition scores.

calculated, and correlation between different parameters was examined. The reliability of differences was assessed using the student's t-test, as well as analysis of variance (ANOVA) using IBM SPSS Statistics 27. Significant differences were identified with a significance threshold set at  $p < 0.05$ .

## RESULTS AND DISCUSSION

**Live weight and body reserves:** At first calving, cows in the group 3 exhibited a higher average live weight (554 ± 46.72 kg) compared to groups 1 and 2 (505 ± 96.55 kg; 462 ± 38.73 kg) respectively (Table3). During the second calving, an overall increase in live weight was observed in all three groups, with increases of (+169 kg, +212.5 kg, +123.5 kg). Thus, body weights (505 ± 96.55; 462 ± 38.73; 554 ± 46.72 kg) at first calving varied significantly among the different groups ( $P < 0.05$ ). In contrast, the body weight gain of cows during entire experiment showed no significant difference among the three groups ( $p < 0.05$ ). This finding is also supported by the observations made in northeastern Algeria by Merdaci and Chemmam in 2016, which showed an increase in live weight during the first two lactations for Montbéliarde cows from 580 ± 45 kg to 607 ± 42 kg.

**Milk production:** The results regarding average milk

production are presented in Table 4. During their first lactation, cows initiated their daily production with values of 15.5 ± 4.84 kg, 11.8 ± 2.31 kg, and 14.5 ± 4.37 kg, respectively, then reaching peak production of 25.2 ± 3.54 kg, 23.2 ± 1.94 kg, and 25.3 ± 1.38 kg, respectively, in the three groups. 6 439.5 ± 743.02, 6 065 ± 647.04 and 6 347 ± 886.78

Thus, G3 generated the highest production throughout first lactation, reaching 6459 ± 743.02 kg. During the second lactation, initial milk performance ranged from 18 to 20 kg per day, marking an increase compared to the first lactation where cows continued to grow, particularly the mammary system, to achieve better milk production capacity over time. As a result, ration 1 recorded the highest performances during the first two lactations, with a total production of 12 879 kg. Our results showed relatively high yields compared to those obtained in the Kabylie mountain region of Algeria by Belkheir *et al.* (2015), who reported an estimated milk yield of 4 805 ± 1 489 kg/cow/year. They also surpassed the performances observed in the Upper Cheliff by Belhadia and Yakhlef in 2013 (3 413 ± 471 kg) in Montbéliarde cattle, in Médéa by Soumeiya, *et al.* in 2012 (4 884 kg), and in Tizi-Ouzou by Bouzida *et al.* in 2010 (4 074 ± 1 278 kg). The optimal persistence coefficient, set at 90%, indicated that during lactation period, the average milk production of an individual declined by 10% each month (Hanzen, 2008). In our study, the lactation persistence was 92.7%, 93.2%, and 81.7% for the three groups respectively. These results revealed that the milk production of Group 3 decreased by 18.3% each month, which significantly exceeded the recommended optimal value.

**Physicochemical characteristics of milk:** During both lactations, Group 3 consistently had higher concentrations of milk fat compared to the other groups (Table 5). In contrast, Group 1 showed more fluctuations, with average milk fat levels of 31.53 ± 1.96 g/kg during the first lactation, increasing to 35.30 ± 2.56 g/kg during the second lactation. Group 2 maintained intermediate levels throughout both lactations, with rates of 32.15 ± 3 g/kg and 33.44 ± 2.02 g/kg of milk fat, respectively. The variations in milk fat levels among the different groups can be attributed to differences

Table 4. Milk production during the first two lactations for the three diets

Lactation cycle	Milk production	Groups		
		G 1	G 2	G 3
L 1	MP <sub>Early</sub> (kg/j)	15.5 ± 4.84 <sub>a</sub>	11.8 ± 2.31 <sub>b</sub>	14.5 ± 4.37 <sub>b</sub>
	MP <sub>Max</sub> (kg/j)	25.2 ± 3.54 <sub>a</sub>	23.2 ± 1.94 <sub>a</sub>	25.3 ± 1.38 <sub>a</sub>
	MP <sub>305</sub> (kg)	6141 ± 906.4 <sub>a</sub>	5691 ± 503.96 <sub>a</sub>	6459 ± 591.86 <sub>b</sub>
L 2	MP <sub>Early</sub> (kg/j)	20 ± 2.96 <sub>a</sub>	19.8 ± 6.27 <sub>a</sub>	18.2 ± 6.73 <sub>a</sub>
	MP <sub>Max</sub> (kg/j)	27.8 ± 1.94 <sub>a</sub>	28 ± 3.16 <sub>a</sub>	25.2 ± 2.48 <sub>b</sub>
	MP <sub>305</sub> (kg)	6738 ± 579.65 <sub>a</sub>	6439 ± 790.12 <sub>b</sub>	6490 ± 1181.7 <sub>b</sub>
PC		1.08	1.07	1.25
Total	MP (L1, L2)	12879 ± 743.02	12130 ± 647.04	12694 ± 886.78

<sup>abc</sup> significant difference on the values of the same line ( $p < 0.05$ ). MPEarly: Early milk production; MPmax: Maximum milk production; MP 305: Milk production during lactation period. PC: Milk yield persistency coefficient

Table 5. Physicochemical characteristics of milk during the first and second lactation

Groups	Lactation 1						
	pH	Fat (g/kg)	protein (g/kg)	Density	DDE (g/kg)	TS (g/kg)	Lactose (g/kg)
G 1	6.64± 0.12 <sub>a</sub>	31.53±1.96 <sub>a</sub>	30.71± 0.84 <sub>a</sub>	1030.41 ± 0.93 <sub>a</sub>	82.16 ± 5.49 <sub>a</sub>	113.69±6.99 <sub>a,b</sub>	45.8 ± 0.12 <sub>a</sub>
G 2	6.67± 0.06 <sub>a</sub>	32.15 ± 3 <sub>a</sub>	30.13± 1.18 <sub>a</sub>	1029.16 ± 1.37 <sub>a</sub>	82.66 ± 3.31 <sub>a</sub>	112.44 ± 8.45 <sub>a</sub>	45 ± 0.15 <sub>a</sub>
G 3	6.71± 0.04 <sub>a</sub>	35.47± 2.68 <sub>b</sub>	30.38 ± 1.6 <sub>a</sub>	1030.01 ± 0.68 <sub>a</sub>	85.34 ± 1.31 <sub>a</sub>	120.81 ± 3.38 <sub>b</sub>	46.4 ± 0.09 <sub>a</sub>
Lactation 2							
G 1	6.69± 0.14 <sub>a</sub>	35.30± 2.56 <sub>a</sub>	30.75± 0.61 <sub>a</sub>	1030.05± 0.75 <sub>a,b</sub>	84.66 ± 1.39 <sub>a</sub>	120.75 ± 1.72 <sub>a</sub>	45.8 ± 0.09 <sub>a</sub>
G 2	6.73± 0.02 <sub>a</sub>	33.44± 2.02 <sub>a</sub>	29.8 ± 0.5 <sub>a</sub>	1029.19 ± 0.51 <sub>a</sub>	82.59 ± 0.94 <sub>b</sub>	116.54 ± 2.78 <sub>b</sub>	44.7 ± 0.06 <sub>a</sub>
G 3	6.70± 0.01 <sub>a</sub>	35.23± 1.51 <sub>a</sub>	30.68±0.27 <sub>a</sub>	1029.94 ± 0.38 <sub>b</sub>	82.59±0.71 <sub>a,b</sub>	120.59 ± 1.76 <sub>a</sub>	45.5 ± 0.04 <sub>a</sub>

<sup>abc</sup> significant difference on the values of the same column ( $p < 0.05$ ). DDE: Defatted dry extract; TS: Total solids.

in fiber content in the three diets. This, in turn, affects the production of acetic acid and ultimately, the levels of fat in the milk. Additionally, the chopping fineness of the diets also plays a role in the fiber content and its digestibility (Baumont *et al.* 2011). Studies by Al-Zahal *et al.* (2009) and Perfield *et al.* (2007) have found that cows fed a diet low in fiber and polyunsaturated fatty acids may develop subacute ruminal acidosis without a decrease in milk fat content.

Additionally, the cows' ability to efficiently digest nutrients from their diet plays a crucial role in the supply of metabolizable energy, which is essential for maintaining optimal levels of milk-fat. Our findings showed a lower average fat content compared to a study conducted in the central-north region of Algeria by Kaouche-Adjlane and Mati (2017), where they reported an average of 37.8 g/kg in low-yield dairy farms (3 053 kg). This difference can be attributed to the dilution effect of milk, as explained by Labarre *et al.* (1994). On the other hand, our results are higher than those reported in the province of Tissemsilt by Elhadj *et al.* (2015) (25.14 g/kg) and in the high plateaus of Cheliff by Remane *et al.* (2016) (32.00 ± 3.60; 29.76 ± 0.68 g/Kg), respectively for the Montbéliarde breed during the 1<sup>st</sup> and 2<sup>nd</sup> lactations.

Overall, there was a slight variability in protein levels

among the different groups. During both lactations, Group 2 consistently exhibited lower protein levels compared to the other groups. In contrast, Group 1 consistently showed the highest average protein levels with 30.71 ± 0.84 g/Kg and 30.75 ± 0.61 g/Kg during the two lactations. The group fed with ration 3 also recorded relatively high protein levels. It is worth noting that there were significant differences in protein levels between the 1<sup>st</sup> and 2<sup>nd</sup> lactation ( $P < 0.05$ ).

The variations observed in milk protein levels among the three diets can be attributed, on one hand, to the quantity and quality of proteins present in these diets, and on the other hand, to the balance of amino acids within these proteins, notably lysine and methionine, which can promote better protein synthesis in milk (Raggio, 2006). Diet 1 stood out with a higher quantity of digestible proteins compared to the other diets with 1 858.49 g; 1 850.82 g and 1 698.57 g of PDI (proteins truly digested in the small intestine), respectively. Furthermore, energy is an essential component to support the metabolic processes involved in milk protein synthesis. Thus, diets richer in energy promote milk protein synthesis (Beckers, 2013). This observation was confirmed by Group 3, which maintained an intermediate protein level despite its lower quantity of digestible proteins compared to the other diets (1698.57 g of PDI). This was consistent with the findings of Matallah

Table 6. fertility indicators according to three different diets

Fertility Indicators (days)	Groups		
	G 1	G 2	G 3
Age at first mating	644.16 ± 180.41 <sub>a</sub>	642.66 ± 163.50 <sub>a</sub>	667.5 ± 64.56 <sub>a</sub>
Age at first calving	924.16 ± 180.40 <sub>a</sub>	922.66 ± 164 <sub>a</sub>	947.5 ± 64.7 <sub>a</sub>
Calving interval	370 ± 24.70 <sub>a,b</sub>	360 ± 71.01 <sub>a</sub>	404 ± 40.62 <sub>b</sub>
Calving to first service interval	77.16 ± 25.03 <sub>a,b</sub>	75.16 ± 29.23 <sub>a</sub>	107.83 ± 43.89 <sub>b</sub>
Calving to conception interval	114 ± 65.46 <sub>a</sub>	98.83 ± 60.36 <sub>a</sub>	121.16 ± 42.33 <sub>a</sub>
Success of FSC (%)	66,67 <sub>a</sub>	83,33 <sub>b</sub>	66.67 <sub>a</sub>
Coital index	1,33 <sub>a</sub>	1.17 <sub>a</sub>	1.33 <sub>a</sub>

<sup>abc</sup> significant difference on the values of the same line ( $p < 0.05$ ). FSC: First service conception; Coital index: Number of inseminations for one successful insemination

*et al.* (2015) in the northeastern region of Algeria, which also showed an increase in milk protein content ( $32.2 \pm 6.1$  g/Kg) with a higher energy-rich diet. Other studies have also reported similar results, with Merdaci *et al.* (2018) finding an average milk protein level of  $33.5 \pm 2.1$  g/Kg, Bouamra *et al.* (2016) recording a value of ( $32.5 \pm 0.19$  g/Kg) for the Montbéliarde breed.

**Reproductive performances:** The results in Table 6 indicated that Group 2 had the shortest calving interval with  $360 \pm 71.01$  days, followed by Group 1 with  $370 \pm 24.70$  days. Group 3 showed higher average with  $404 \pm 40.62$  days, exceeding the calving interval target set by Hanzen (2009), who recommends approaching as closely as possible to 365 days. However, in western Algeria, Zineddine *et al.* (2010) recorded an average calving interval of  $470 \pm 111$  days. Furthermore, Belhadia and Yakhlef in 2013, as well as Mefti (2016), had observed average calving interval of  $387 \pm 52$  days and  $470.96$  days, respectively.

According to Klingborg (1987), it is recommended to inseminate cows during the first 90 days postpartum. Our results indicated that the average interval between calving and first mating was  $86.69 \pm 32.71$  days. Groups 1 and 2 had closer intervals between calving and first mating with  $77.16 \pm 25.03$  and  $75.16 \pm 29.23$  days respectively, while Group 3 displayed a longer average interval with  $107.83 \pm 43.89$  days. However, these results were lower than those reported by Mefti (2016) with  $94.50 \pm 53.09$  days, Haou *et al.* (2021) with  $108 \pm 80.4$  days, and Zineddine *et al.* (2010) with  $159 \pm 89$  days. Therefore, Group 2 generally showed more favorable performance in terms of age at first mating, age at first calving and calving interval.

Using total mixed rations for dairy cows ensured that they received a complete and balanced diet with every bite, reducing the need for sorting and separating ingredients. This approach will also make it easier to include a variety of base by-products in the feed. Additionally, cows experience fewer digestive problems and have more stable milk components. These optimized rations allow cows to reach their full genetic potential, leading to sustainable maximum milk production even in challenging local climates. These findings highlight the effectiveness of TMR feeding as a promising strategy for improving the overall performance of dairy herds.

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