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# Body Condition Score and Biochemical Indices Change in Montbeliard Dairy Cattle: Influence of Parity and Lactation Stage

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**Abstract:** This study aimed to compare BCS status with some plasma concentrations of major substrates (urea, albumin, total cholesterol, glucose) and minerals (calcium, phosphorus, magnesium) according to parity number and stage of lactation. This study was conducted on 135 Montbeliard cows raised in northeastern Algeria under a semi-arid climate. Among the independent indices evaluated, a significant effect of the physiological stage was observed on urea, glucose, total cholesterol, magnesium and phosphorus. Results revealed that dairy cows developed hyperglycemia and hypo-uremia throughout the lactation and dry period. Hypo-minerals were recorded during the dry period. Our data indicated the need for metabolic profile monitoring in dairy cattle based on their physiological status for providing animal welfare and to manage and prevent the deficiencies typical of high producing Montbeliard cows.

**Key words:** BCS · Biochemical Profile · Dairy Cattle · Dry Period · Lactation Period · Pregnancy

## INTRODUCTION

The deficiency in the nutrition of dairy cows can influence many biochemical and physiological processes. Consequently, they perturb the relation between the metabolic capacities of animals required for the production of milk and, as a result, cause metabolic disorders. So, the nutritional status of ruminants is the subject of numerous researches in the energy, nitrogen and mineral fields and this because of its repercussions on the performances of these animals and its role in the appearance of pathological disorders. In fact, the appreciation of the nutritional state through the blood parameters developed during last years [1]. The selection of the blood biochemical markers allow the detection of the substantial food imbalance susceptible to pull different pathologies (Balance nitrogen/energy, mineral status and liver function) [2]. In this regard, previous studies on dairy cows have been carried out to generate biochemical profiles according to their physiological statue and lactation stage [3, 4]. Generally, it is not recommended to include peri-partum cows in MPT because of their abnormal physiological state, which makes difficult to interpret their blood components [3, 4].

Information about the biochemical profile changes according to the different physiological states of the dairy cows in Algeria are very insufficient, more particularly, in the European Montbeliard cows imported and maintained in Algerian semi-arid highlands. So, the present study was undertaken to study the changes of the blood biochemical constitutions according to the age and the physiological stage of Montbeliard breed cows at Setif highlands region in the northeast of Algeria.

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## MATERIALS AND METHODS

**Region of Study:** The present study was conducted in the region of Setif, a vast plain in northeastern Algeria, covering 365, 000 ha of arable land and containing 150, 000 heads of cattle (10% of the national livestock). Our investigation was carried out in twenty-eight private farms located in four municipalities belonging to the same bioclimatic floor in the north-east of the department of study (Ain Elkbira, Babor, Sergj Elghoul and Ouled Adouane). These localities were characterized by a semi-arid continental climate with a very variable level of precipitation from one year to another and from north to south of 600 to 200 mm per year and the average temperatures oscillated from 5°C (January) to 26°C (July). The average altitude varies between 700 and 1300m.

**Animals:** This study was performed during 2015. A total of 135 cows were considered in a random sampling of 20% per farm. The studied animals aged between 3 and 11 years, were apparently healthy, with average milk yield of 5500 kg /305 days. They were randomly selected. Animals were divided according to their parity into primiparous (n = 75) and multiparous (n = 60) and according to physiological stages into early lactation form 30 to 90 days in milk (n = 59), mid lactation from 90 to 180 days in milk (n = 60) and dry animals during their dry period (n = 16).

The studied animals were kept under similar dietary and managerial practices on a semi-intensive livestock system. The dietary calendar during the winter (November-February) that depended on the distribution of hay (Meadows or oats), sorghum silage and commercial concentrate as complementary ration. During Spring, herds exploit natural grasslands and fallows, whereas during both summer and autumn, residues were the effects of grass mowing and / or cereal stubble provide part of the diet. Animals were kept in tie-stalls. Natural breeding was commonly used but sometimes artificial insemination was conducted.

**Blood Sampling and Determination of Biochemical Parameters:** Blood samples were taken from coccygeal vein from each cow between 08:00 and 10:00 (Approximately two hours after feeding and milking). This sampling time was strictly maintained during the whole period of the study. The samples were taken on sterile vacuum tubes containing an anticoagulant (Lithium heparin). The concentration of glucose immediately estimated after blood collection using an Accu-Chek Active blood glucose meter. Plasma was collected in two hours after blood collection by centrifugation at 5000 rpm for 5 minutes. Blood biochemical analysis were assayed using spectrophotometry and commercial kits (Spinreact®) appropriate for each test (Table 1). The BCS assessment was done by the same person on the score of 1: very thin to 5: very fat according to Edmonson grill of 0.25 deviations [5].

**Statistical Analysis:** The Statistical analyses of the data were performed using Excel Stat 2014 software. One-way analysis of variance was applied (ANOVA) to observe the differences between the cow groups and between the physiological periods. The descriptive statistics (Mean, minimum, maximum and standard deviation) were estimated. The significance was attributed when $P < 0.05$, $P < 0.01$ and $P < 0.001$.

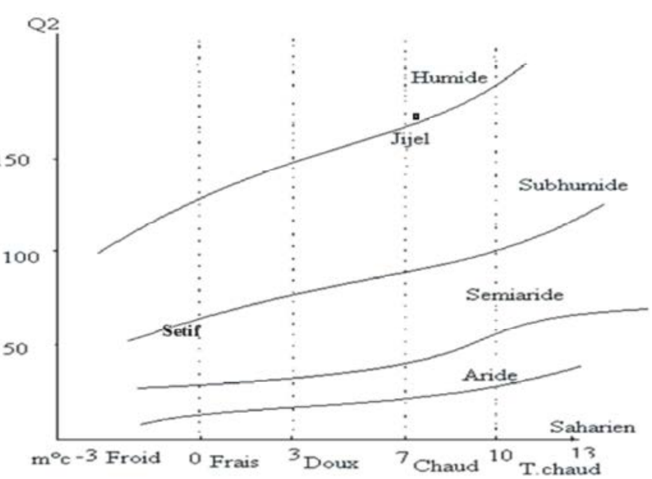


Fig. 1: Bioclimatic properties of the study region according to different algerian ombrothermal stages

Table 1: Blood parameters, analytical methods and quality of the laboratory tests

| Parameter | Analytical Method | Intra-test variation (CV%) | Inter-test variation (CV%) |
|---|---|---|---|
| Urea | Urease and glutamate dehydrogenase GLDH method | 2.08 | 3.4 |
| Albumin | Green bromcresol albumin method | 1.41 | 1.99 |
| Total cholesterol | Enzyme Colorimetric Test CHOP –PAP | 2.08 | 2.56 |
| Calcium | Colorimetric: o-cresolphtalein complexone | 1.02 | 1.63 |
| Magnesium | Xylidyl blue method | 1.30 | 2.83 |
| Phosphorus | Phosphomolybdate | 0.77 | 1.41 |

## RESULTS

**Mean Values of BCS and Biochemical Blood Parameters:** The mean values of BCS and blood biochemical parameters of studied cows (n = 135) are summarized in Table 2. The mean BCS found in this study was 3.38 ± 0.55 with extreme values of 2 and 4.5. The plasma concentrations of the following substrates: glucose, total cholesterol, urea and albumin were: 0.64 ± 0.08 g/l; 1.29 ± 0.41 g/l; 0.15 ± 0.04 g/l and 2.72 ± 0.56 g/l respectively. On the other hand, the blood concentrations calcium, magnesium and phosphorus were 89.27 ± 13.42 mg/l; 20.3 ± 5.6 mg/l and 43.2 ± 22.1 mg/l respectively.

**Effect of Lactation Stage on the BCS and Blood Biochemical Indices:** The Figure 2-5 presents the effect of lactation period on body condition score and on blood biochemical parameters. It appears that the body condition score and the plasma concentration of biochemical parameters vary significantly depending on the physiological stages of lactation. Decreased BCS were observed during early lactation, then increased significantly ($P$<0.05) duringmid-lactation and dry period (3.19 *vs* 3.46 and 3.78) respectively (Figure 2).

Blood glucose levels varied significantly from 0.6 ± 0.09 g/l during early lactation to 0.66 ± 0.07 g/l during dry period (Figure 3). In the present study, blood cholesterol concentrations showed a significant increase ($P$<0.05) up to mid-lactation (1.20 ± 0.38 *vs* 1.46 ± 0.42 g/l) then decreased during dry period (1.46 ± 0.42 *vs* 0.99 ± 0.23 g/l) (Figure 3). Statistical analysis showed no significant changes of blood urea and albumin concentrations during all lactation stages (0.14 ± 0.03 to 0.16 ± 0.05 g/l and 2.68 ± 0.49 to 2.76 ± 0.51 g/l) respectively (Figure 3). Finally, the changes of the three minerals; calcium, phosphorus and magnesium, showed significantly higher values for P and Mg during early lactation compared to mid-lactation and dry period (Figure 4). However, no significant variation for Ca mentioned throughout lactation (Figure 4). Finally, the changes of phosphorus and magnesium showed significant increase during early lactation compared to mid-lactation and dry period. However, no significant variation mentioned for Ca during all stage of lactation (Figure 4).

**Effect of Parity Stage on BCS and Biochemical Blood Indices:** From the tabulated data (Table 3), it could be noticed that the multiparous cows had a mean BCS (3.50 ± 0.55) significantly higher ($P$ <0.05) than of the primiparous (3.28 ± 0.53). However, the mean values of the blood biochemical parameters were similar for both categories without significant effect of parity was found. In this regard, the decortication of obtained results according to the different lactation stages showed that the BCS displayed a significant difference between the two cow groups; primiparous and multiparous, only during early lactation ($P$ <0.05) (3.37±0.55 *vs* 3.06±0.46).

Table 2: Mean values of body condition score and biochemical indices evaluated in Montbeliard dairy cows

| Biochemical constants | *N* | *Mean±SD* | Minimum | Maximum |
|---|---|---|---|---|
| BCS | 135 | 3.38±0.55 | 2 | 4.50 |
| Glucose g/l | 135 | 0.64±0.08 | 0.31 | 0.84 |
| Total cholesterol g/l | 135 | 1.29±0.41 | 0.56 | 2.96 |
| Urea g/l | 135 | 0.15±0.04 | 0.09 | 0.30 |
| Albumin g/l | 135 | 2.72±0.56 | 1.26 | 3.95 |
| Calcium mg/l | 135 | 89.27±13.42 | 52.47 | 123.88 |
| Magnesium mg/l | 135 | 20.30±05.60 | 0.91 | 42.00 |
| Phosphorus mg/l | 135 | 43.20±22.10 | 10 | 106.20 |

BCS: Body condition score; SD: standard deviation

Table 3: The effect of parity on the change of BCS and metabolic profiling

| | | *Primiparous* | | *Multiparous* | | Primiparous x multiparous |
|---|---|---|---|---|---|---|
| | BCS & biochemical constants | *n* | *Mean±SD* | *n* | *Mean±SD* | *p* |
| Total cows | BCS | 75 | 3.28±0.53 | 60 | 3.50±0.55 | *p<0.05* |
| | Glu g/l | 75 | 0.65±0.07 | 60 | 0.63±0.10 | *p>0.05* |
| | Chol g/l | 75 | 1.34±0.43 | 60 | 1.22±0.38 | *p>0.05* |
| | Urea g/l | 75 | 0.15±0.04 | 60 | 0.15±0.05 | *p>0.05* |
| | Alb g/dl | 75 | 2.66±0.57 | 60 | 2.79±0.55 | *p>0.05* |
| | Ca mg/l | 75 | 91.31±13.52 | 60 | 86.76±13.08 | *p>0.05* |
| | P mg/l | 75 | 39.24±20.18 | 60 | 48.19±22.76 | *p>0.05* |
| | Mg mg/l | 75 | 21.04±5.91[a] | 60 | 19.57±5.18 | *p>0.05* |
| Early lactation | BCS | 27 | 3.06±0.46[a**] | 24 | 3.37±0.55 | *p<0.05* |
| | Glu g/l | 27 | 0.61±0.06[a*] | 24 | 0.57±0.11[a*] | *p>0.05* |
| | Chol g/l | 27 | 1.26±0.40[a*] | 24 | 1.1±0.33[a*] | *p>0.05* |
| | Urea g/l | 27 | 0.16±0.05[a] | 24 | 0.16±0.05[a] | *p>0.05* |
| | Alb g/dl | 27 | 2.70±0.57 | 24 | 2.84±0.41 | *p>0.05* |
| | Ca mg/l | 27 | 90.95±12.75 | 24 | 88.75±15.85 | *p>0.05* |
| | P mg/l | 27 | 22.9±6.6[a] | 24 | 20.6±6.2 | *p>0.05* |
| | Mg mg/l | 27 | 44.9±25.9[b] | 24 | 56.4±29.8 | *p>0.05* |
| Mid lactation | BCS | 32 | 3.41±0.53[b] | 28 | 3.52±0.56 | *p>0.05* |
| | Glu g/l | 32 | 0.67±0.06[b] | 28 | 0.66±0.07[b] | *p>0.05* |
| | Chol g/l | 32 | 1.53±0.43[b*] | 28 | 1.38±0.39[b] | *p>0.05* |
| | Urea g/l | 32 | 0.14±0.03[b] | 28 | 0.14±0.03[a] | *p>0.05* |
| | Alb g/dl | 32 | 2.71±0.61 | 28 | 2.67±0.67 | *p>0.05* |
| | Ca mg/l | 32 | 92.28±14.66 | 28 | 86.88±11.35 | *p>0.05* |
| | P mg/l | 32 | 19.4±0.50[b] | 28 | 19.5±0.41 | *p>0.05* |
| | Mg mg/l | 32 | 36.5±14.2[b] | 28 | 42.4±16.2 | *p>0.05* |
| Dry period | BCS | 8 | 3.68±0.34[b] | 8 | 3.87±0.40 | *p>0.05* |
| | Glu g/l | 8 | 0.66±0.07[b] | 8 | 0.67±0.05[b] | *p>0.05* |
| | Chol g/l | 8 | 0.96±0.18[c*] | 8 | 1.02±0.29[a*] | *p>0.05* |
| | Urea g/l | 8 | 0.18±0.03[c] | 8 | 0.12±0.01[b] | *p<0.05* |
| | Alb g/dl | 8 | 2.29±0.35 | 8 | 3.07±0.22 | *p<0.05* |
| | Ca mg/l | 8 | 89.16±13.65 | 8 | 80.35±7.75 | *p>0.05* |
| | P mg/l | 8 | 19.1±3.0[b] | 8 | 16.6±4.5 | *p<0.05* |
| | Mg mg/l | 8 | 24.6±5.9[a] | 8 | 43.6±6.8 | *p<0.05* |

Different letters on the same column indicate significant difference by stage at P <0.05, * at P <0.01 ** at P<0.001; BCS: Body condition score; SD: standard deviation

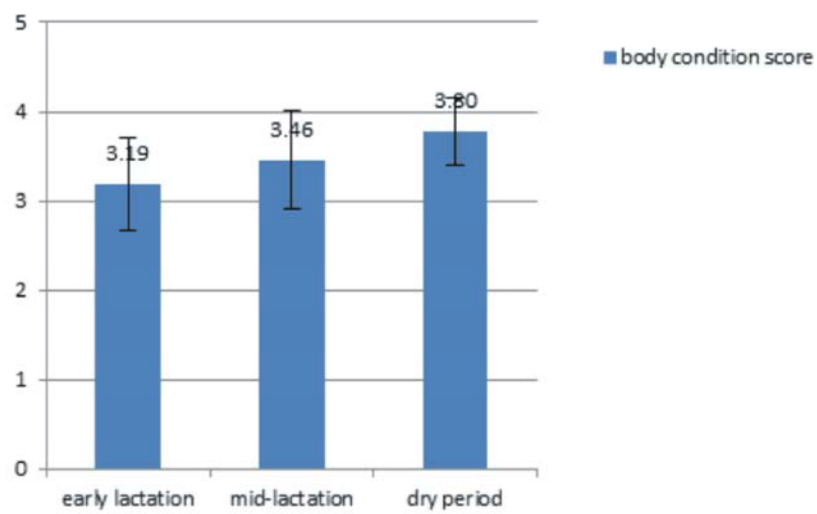


Fig. 2: Effect of stage of lactation on body condition score

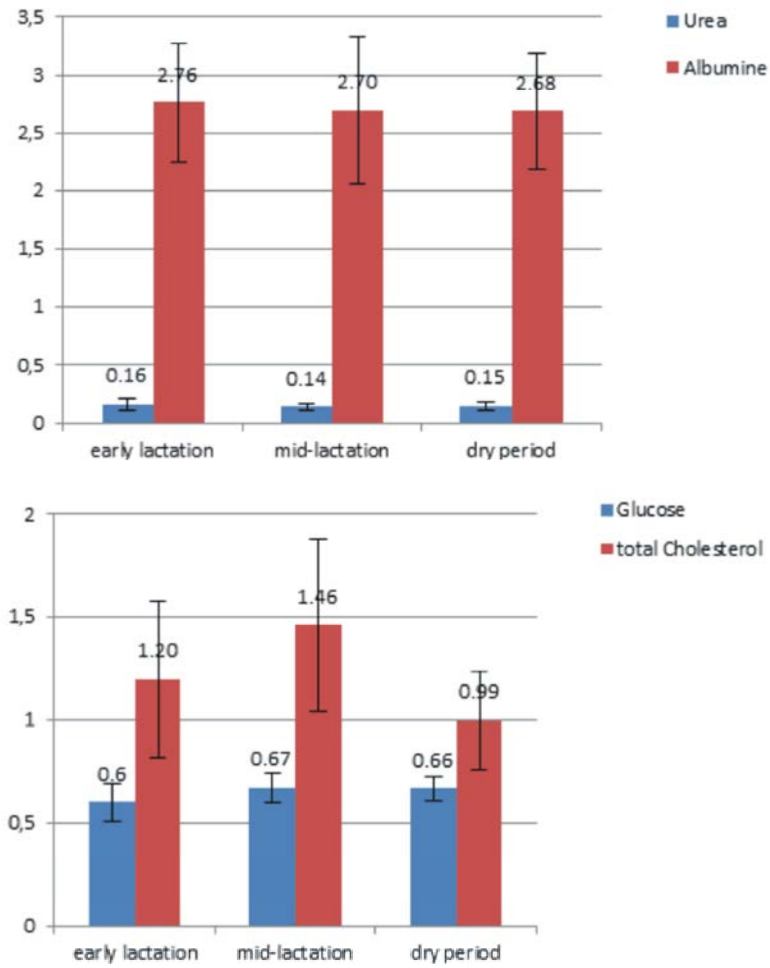


Fig. 3: Effect of stage of lactation on plasma concentrations of different blood indices

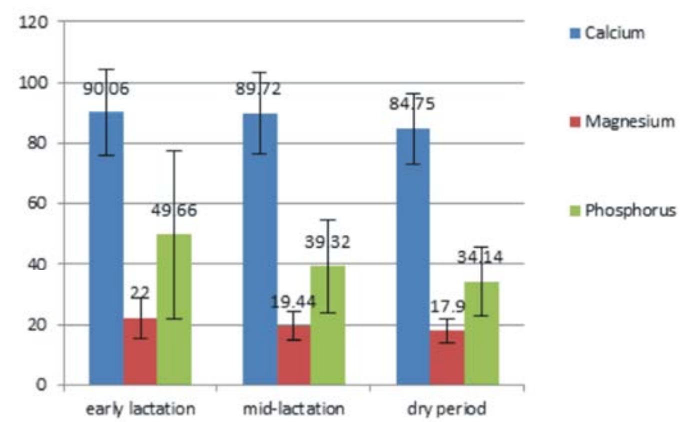


Fig. 4: Effect of stage of lactation on plasma concentrations of minerals

During mid-lactation, we did not observe a significant effect of parity on BCS and on all blood parameters. During the dry period, plasma concentrations of urea and phosphorus were higher ($P$<0.05) in primiparous compared to multiparous cows (0.18 ± 0.03 *vs* 0.12 ± 0.01 g/l and 19.1 ± 3.0 *vs* 16.6 ± 4.5 mg/l) respectively. However, albumin and magnesium levels were significantly elevated ($P$<0.05) in multiparous compared to primiparous cows (16.6 ± 4.5 *vs* 2.29 ± 0.35 g/l and 43.6 ± 6.8 vs. 24.6 ± 5.9 mg/l) respectively.

## DISCUSSION

The objective of this investigation was to study the effect parity (Primiparous and multiparous cows) and lactation stage (Early, mid-lactation and dry period) on the BCS and biochemical blood status in Montbeliard dairy cattle. Previous studies reported that stage of lactation is one of the important causes of variation of blood metabolite concentrations in dairy cows and so the variations recorded during the different physiological phases [6, 7].

The average value of BCS obtained in this study reflects that imported Montbeliard dairy cows breed is well adapted to the semi-arid climate. Therefore, the body condition score displays significantly higher score in mid-lactation and dry period compared to early lactation. However, our results showed that the difference in BCS between primiparous and multiparous was noted during early lactation, in fact, multiparous Montbeliard cows develop regular adaptation compared to primiparous cows.

In this study, the mean value of blood urea concentration (0.15 ± 0.04 g/l) was within reference range values reported by Brugère-picoux [8]. Nevertheless, it was lower to those described by Verriele and Bedouet [9], Sevinc *et al*. [10]. And it was also lower to those found in the region of Constantine which is in the same climatic conditions as the region of our study by Kayoueche [11], Boudebza [12], Metref [13] and Mouffouk [14]. This difference in results suggests the influence of multitude of interrelated factors, in particular: the intake of dietary proteins; amino acid components of diets, protein intake versus needs; hepatic and renal function, muscle tissue breakdown, carbohydrate and rumen degradability [15, 16].

The blood urea concentration found in this study during early lactation was significantly increased ($P$<0.05) compared to other stages of lactation. Several previous studies revealed a significant effect of stage of lactation on blood urea concentration [1, 17]. Poso and Lindberg [18] found a decrease in blood urea levels after parturition, which is consistent with our results. Similarly, the pattern of uremia variations is similar to that described by Poncet [2] in the Holstein breed raised in the region of the island of the meeting. During the dry period, improvement of metabolic activities, particularly the increase in protein catabolism to the detriment of protein synthesis and the high availability of glucose for oxidation increase urea production [19]. Furthermore, our results showed an increased blood urea levels in primiparous cows ($P$> 0.05) during dry period. Contrary, Payne and Payne, (1987) [20] reported an increased blood urea levels in multiparous cow. This could be related to age differences in protein metabolism.

Albumin is synthesized in the liver and is the protein primarily responsible for the oncotic pressure in plasma [21]. Albumin has a relatively short half-life and may reflect protein deficiency problems over a period of one or two months [8]. The mean plasma albumin concentration is within the reference range value reported by Brugère-picoux [8]. In this study, lactation had no significant effect on serum albumin concentrations as lactation advance there was no significant decrease in albumin concentrations (Figure 3). According to Poncet [2] blood albumin concentration at calving is between 33 and 35 g/l and remains almost constant during the first half of lactation. Some studies noted decreased serum albumin levels with progression of lactation [22, 23]. This may be caused by maternal protein requirements for milk production and synthesis of immunoglobulins. According to Grummer [24] Plasma albumin concentrations are reduced in cows with fatty liver, which may indicate a reduction in the ability of the liver to synthesize protein when triglyceride content is elevated.

During the dry period, the plasma value of albumin was significantly increased in multiparous cows compared to primiparous (3.07 ± 0.22 *vs* 2.29 ± 0.35 g/dl). According to Rossato *et al.* [25] cows of more number of lactations have a better adaptation to the challenge of milk production.

Glucose metabolism is unique in ruminants because they absorb essentially no preformed glucose from the gut [21]. In this study, the blood glucose levels during mid-lactation and dry period was significantly elevated compared to early lactation period (0.66 ± 0.06 g/l and 0.67 ± 0.07 g/l *vs*. 0.60 ± 0.09 g/l). Similar results were obtained by Slanina *et al*. [26]. The drop of blood glucose concentration after calving is caused by the exploitation of a large amount of blood glucose in the mammary gland for lactose synthesis [27, 28]. According to Kaneko *et al.* [29] the major portion of the glucose uptake by the mammary gland provides for the biosynthesis of milk. The glucose and galactose moieties of lactose are derived from blood glucose. However, Takarkhede *et al.* [30] and Goff [31] reported an increase in serum glucose after parturition. The increased glucose levels during early lactation in ruminants ascribed to developed glucose sparing mechanisms mostly in mammary gland to prevent hypo-glycaemia [31]. This finding was confirmed by blood establishment of peri-partum glucose in Holstein cows raised in Saudi Arabia [32]. In parallel with the high glucose demand for postpartum lactation, two factors contribute to the lower in blood glucose; low dietary intake after calving and large fermentation of food carbohydrates in the rumen. It should be mentioned, that most of the previous works has showed that there was a decrease between 8 and 18% of the glucose concentration between the last month of gestation and the first month of lactation [2, 26]. However, other reports have indicated that increased glucose levels during pregnancy were associated with stress and increased secretion of glucocorticoids and epinephrine that stimulate glycogenolysis in the liver [33, 34].

The present study did not show a significant effect of age of cow on blood glucose levels. A similar result was reported by Radostits *et al*. [35]. However, Rossato *et al.* [25] indicated that older cows have a better ability to maintain homeostasis of glucose, mainly during the peak of milk production ($6^{th}$ week). According to Van Knegsel *et al.* [36] the decreased plasma glucose levels were associated with decreased reproductive performance.

The results obtained in this study reported that the average level of total blood cholesterol was $1.29 \pm 0.41$ g/l (Table 2). The mean value obtained is within the reference range value cited by Brugère-picoux [8]. In the present study, the high level of blood cholesterol was reported during mid-lactation compared to early and dry period ($P$ <0.05) (Figure 3). The increased plasma cholesterol concentration after calving was reported previously in dairy cows in Egypt and Brazil [37-39]. hypercholesterolaemia can be considered physiological during lactation, either as a result of lipid mobilization caused by glucagon or to an increase in the synthesis of plasmatic lipoproteins. However, the increase in cholesterol concentrations may be due to a greater energy demand than that supplied by the offered diet [40]. Higher serum cholesterol concentration values can be a result from the supplementation of essential fatty acids from the diet [38]. These variations, reflecting a state of energy deficiency characteristic of the beginning of lactation [41, 42]. In fact, cholesterolemia is even higher (20-25%) when the cow is fat at calving and she loses a lot of body condition in post partum [42, 43]. On the other hand, lower serum cholesterol concentrations in the first weeks postpartum have been related with fatty liver [44, 45]. In the contrary, Macros *et al*. [46] reported that in dairy cows, the lowest levels, of serum total cholesterol was observed at the onset of lactation. These variations were related to the physiological adaptations of dairy cows for their energy needs during lactation. In addition, our data also indicate that there was a decrease in serum cholesterol levels during dry period (Figure 3). The decrease in cholesterol was probably attributed to the decrease in food associated with alterations in lipid metabolism [47]. Furthermore, it can be assumed that the observed significant increase of cholesterol levels in lactating cows compared with the period before calving was related to increased requirements for cholesterol of the glands producing steroid hormones [48, 49].

Metabolism of macro minerals plays a significant role in the regulation of physiological functions during pregnancy and lactation. All animals require minerals for growth, reproduction and lactation and they serve as the structural part or components of enzymes and regulate many chemical reactions in the body [50]. Calcium, phosphorus and magnesium, are determining in the appearance of metabolic pathologies causing the Downer Cow (Milk fever, hypomagnesemia ...) and fertility disorders [51, 52]. The body of the animal has a system of homeostasis hydroelectrolytic finely tuned to maintain the blood levels of these macros-minerals. Blood variations in their concentrations must be carefully interpreted because they do not reflect the food status when the homeostatic system is functioning properly [53]. Various workers Agarwal *et al*. [54] and Singh and Vadnere [55] revealed a direct correlation of mineral status of animals with their physiological status and observed disorders and incriminated altered levels of minerals for loss of production and reproduction. Withat, mineral imbalance has been incriminated as a possible cause for repeat breeding [56]. In another study significantly higher levels of P, Ca and Mg maintained normal cycling in cows when compared with repeat breeders [57, 58]. Prajapati *et al*. [59] reported significant low level of serum Ca, P in repeat breeder buffaloes affected with endometritis.

Results obtained in our investigation indicated that Montbeliard dairy cows have a higher calcium concentration at the beginning of lactation compared to the rest of the lactation and dry period, but these variations are not significant ($P$>0.05) (Figure 4). The mean concentration of blood calcium is within the reference range value described by Brugère-picoux [8]. Several authors showed that blood calcium concentration changes with lactation [60-62]. In this respects, the general profile described in dairy cows is common to many authors, indicating a decrease in serum calcium at the beginning of lactation, then increases as the stage of lactation progresses [2, 28]. Montemurro *et al.* [63] reported that Blood Ca level with higher level in the last month of pregnancy and lower level at the end of the lactation period.

According to Braithwaite [64] cited by Knowlton *et al.* [65] the postpartum ruminant is typically in negative Ca balance. A decrease of Ca levels in lactating cow was reported by Ivanov *et al.* [66] and Fikadu *et al.* [67] in lactating ewe and in lactating goat was indicated by Lamraoui *et al.* [21] and Krajnièáková *et al.* [68] respectively. These authors showed that this decrease was in relation with the passage of Ca to the milk during lactation that leads to a several adaptation in the metabolism of this ion. However, the rising levels of plasma Ca in lactation due to high levels of plasma parathyroid hormone in this period which activates osteoclasts and increases the level of calcaemia to mobilize skeletal Ca reserves [69]. Net bone resorption is likely a normal consequence in early lactation due to the rapid increase in demand for Ca to support milk yield [65, 70].

These results could be caused by decreased absorption of precursor metabolites, excessive losses in urine and for production of colostrum [61, 62]. In fact, each liter of colostrum requires 1.0 to 2.0 g of calcium [10].

During our investigation, we noted that older cows tend to have lower serum calcium. This was justified by the reduced efficiency of the intestinal absorption of calcium, which put older cows more exposed to hypocalcemia. In agreement with our results Rosol and Chew [71] indicated that serum calcium is lower in postparturient cows with 2 or more previous lactations compared to cows after their first lactation. According to the same authors, adult cows have a low level of remodeling and few active osteoclasts on bone surfaces. Therefore, new osteoclasts must be formed after the increase of serum parathyroid hormone in response to the lactation-associated hypocalcemia. Cows fed low Ca diets during the latter stages of gestation have a higher degree of bone turnover and increased osteoclast numbers on bone surfaces at parturition which permit them to more effectively maintain serum Ca concentration during lactation.

Although phosphorus levels are not as tightly regulated as calcium, both are minutely related to plasma concentrations of PO4 directly regulated by 1.25 (OH) 2 D3 and indirectly by the negative feedback PTH / calcium [72]. In cattle, there is evidence that high pre-calving phosphorus diet may have a negative impact on calcium homeostasis [73]. As well, much more phosphorus is related to organic compounds such as phospholipids [74, 75]. As a consequence, the precise prediction of P requirements for ruminants was difficult.

Our study indicated a significant difference of stage of lactation on phosphatemia. This parameter is maximal at the early lactation (49.65 ± 27.88 mg / l) compared to the mid-lactation (39.31 ± 15.36 mg / l) and the dry period (34.14 ± 11.56 mg / l). These results express also a significant deficit of P during the dry period. On the other hand, some reports indicate serum phosphorus levels were significantly lower in early lactation [2, 76]. Grünbergand *et al*. [77] found that hypophosphatemia is present in the blood of highly productive Holstein-Friesian cows throughout the postpartum period. The decrease of plasma levels of phosphorus could be caused by the necessity for colostrum synthesis and increased carbohydrate metabolism [78, 79]. According to Goff [72] in dairy cows and goats, the production of colostrum and milk at the onset of lactation draws large amounts of phosphorus out of the extracellular phosphorus pools. This alone will often cause an acute decline in plasma phosphorus levels at parturition. Other studies reported by Bires *et al*. [80], Hejłasz [81], Kovac *et al.* [82] and Zdelar-Tuk *et al*. [83] found very low levels of P at the peak of lactation. However, Campanile *et al.* [84] reported stable level of serum phosphorus (6 mg/dl) in adult buffaloes during different physiological stages. Montemurro *et al.* [63] reported an increasing trend of serum P during pre-partum period (6.3 mg/dl) to 160 days of lactation (7.9 mg/dl). Besides, phosphorus deficiency during dry period has been incriminated in vaginal or uterine prolapse [84].

As was described for calcium, serum phosphorus levels have low ability in multiparous cows. Same result is reported by Rossato *et al.* [25] and Eman *et al.* [39]. Nevertheless, metabolic disorders in older dairy cows reported by other authors [29] may be related to higher milk production.

Magnesium, like calcium, reduces neuromuscular irritability and a reduction in blood concentration causes spontaneous muscle contractions or tetany, it plays also an important role in calcium homeostasis [85]. Same as phosphorus change profile, the results of this study indicate that the lowest magnesium levels are recorded in drying cows (17.9 ± 3.92 mg/l) and that the highest values are noted during the postpartum period (22.01 ± 6.49 mg/l). Minimum but long-term deficiencies during dry period in buffaloes impaired health during following lactation [84]. Overall, the magnesium levels obtained in this study are within the range of previously reported normal values Brugère-picoux [8]. These findings are similar to those obtained by Nejra *et al.* [86] in Holstein cows in Turkey and different to those found by Poncet [2] and Taylor [76] in meeting island. Mg is higher in multiparous cows than in primiparous cows contrary to that of Ca and P.

## CONCLUSION

The expression of the results of the present study in the form of mean values and confidence intervals of the BCS and various blood biochemical parameters allowed us to identify precisely as well as to understand more clearly the effects of parity and stage of lactation on the metabolic status of Montbeliard cows in semi-intensive breeding of semi-arid climate.

It could be noted that energy metabolism is low during the beginning of lactation. However, this period has the highest mineral metabolism compared to the low rates that had been observed in dry period. Otherwise, the mineral status of animals directly reflects their presence, absence, deficiency or excess in either soil or fodder. Mineral deficiency problems commonly cause adverse effects on production and reproduction unless proper dietary supplementations are provided. Urea displays low concentrations along lactation and dry period. As for parity, it does not express any significant effect on the metabolic profile of these dairy cows. This study provides dairy practitioners with basic information for monitoring the metabolic profile of dairy cows and adopting reasonable nutrition strategies based on stage of lactation.

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