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RESEARCH ARTICLE

Correlation between Body Condition Score, Blood Biochemical Metabolites, Milk Yield and Quality in Algerian Montbéliarde Cattle

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ABSTRACT

This study aimed to investigate the correlation between body condition score (BCS), blood biochemical metabolites, milk yield (MY) and quality (Mfat) in Montbéliarde cattle (31 cows) reared in 5 farms of Algerian semi arid area. The BCS was measured in dry and peak of lactation (6 weeks after calving). Blood samples were taken at the time of body condition (BC) measurement for determination of energy (Glucose, cholesterol, triglycerides and B-Hydroxybutyrate), nitrogen (urea and albumin) and mineral (calcium) metabolites. Milk yield was recorded in the 6th week of lactation (peak). A sample of milk for each cow was used to determinate milk fat, density and acidity. The results showed a significant decrease in postpartum BCS accompanied by an increase in cholesterol and B-Hydroxybutyrate (BHB) concentration. The correlation analysis showed that BHB concentration in pre calving was negatively correlated with BCS ($r=-0.321$; $P<0.05$) and cholesterol ($r=-0.308$; $P<0.05$). In postpartum, BCS was negatively correlated with cholesterol ($r=-0.416$; $P<0.05$), urea ($r=-0.366$; $P<0.05$) and BHB ($r=-0.487$; $P<0.05$). However, the level of milk production decreased significantly with high glucose ($r=-0.449$; $P<0.05$) and BHB ($r=-0.514$; $P<0.05$). The fat content increased significantly with blood triglycerides ($r=0.681$; $P<0.05$) and BHB ($r=0.522$; $P<0.05$) concentration, indicating a high mobilization of body reserves used for the synthesis of milk fat. In conclusion, it can be assumed that the rate of BHB seems to be the best indicator of the nutritional status of dairy cows that determines their production level and quality.

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INTRODUCTION

Nutrition is the first item of expenditure in dairy farming. Its management determines the level of production and milk quality. The nutritional level is traditionally enjoyed by body condition scoring which is a practical and reliable tool for estimating energy reserves. Ayres *et al.* (2009) reported a strong correlation between body condition and subcutaneous adipose tissue (0.82 at dry to 0.93 in postpartum; $P<0.001$). This subjective indicator of energy balance is not only used for evaluation of herd nutritional status but also to evaluate its relations with production parameters (Roche, 2007). However, it has been documented that several biochemical indicators of metabolism may be involved in assessing the nutritional status of cows. The measurement of metabolites such as glucose, insulin, cholesterol, free fatty acids (NEFA) and ketone bodies (BHB) are often used to supplement energy balances or body condition to characterize the energy status.

Among the energy metabolites, BHB appears more effective than NEFA because NEFA sensitivity according to Mäntysaari *et al.* (1999) is early (1 week) but BHB is late (3 to 4 weeks). The BHB is low at dry and increases linearly in postpartum particularly in cows' with low-level food, while NEFA attain a peak at the first week and tend to decrease thereafter (Moallem *et al.,* 2004). Perhaps this lag time exists because NEFA provide the substrate for BHB synthesis. This molecule can not be metabolized; it must be excreted through urine or pulmonary path (Laur, 2003). In addition, Clark *et al.* (2005) report that the best prediction of energy balance (EB) ($r=0.84$), if all significant indicators were used, was a linear regression model that included plasma glucose and plasma BHB.

The effect of changes in BCS and serum biochemical parameters on milk production level and quality is well documented. Singh *et al.* (2009) reported that milk yield at peak, and duration of lactation in high producing cows are higher among those with better body condition at dry. This disagrees with the results of Roche (2007) and Jilek *et al.* (2008), who reported that only the postpartum state affects production level. However, Mohammadi *et al.* (2012) observed a positive correlation between milk yield, BHB and glucose.

The present study aims to investigate the relationship between body condition and metabolic markers at dry and postpartum and to clarify the impact of changes on the quantity and quality of milk produced in peak of lactation.

MATERIALS AND METHODS

This work was conducted from February to September 2011 on 31 Montbéliarde cows reared in five farms with acceptable level of feed mastery. The production system was similar for all farms. Body condition score was taken at dry (six weeks before calving) and at lactation peak (6th week of lactation) by the method proposed by Edmonson *et al.* (1989) on a scale of 1 to 5 (1=thin; 5=obese), with interval of 0.5.

Two blood samples were made and a 10ml sample of each cow was taken from the jugular vein. To limit the consumption of glucose from blood into red cells, plasma glucose was determined on site using a portable blood glucose meter "Accu-Chek ®". In the laboratory, blood samples were centrifuged at 4500 RPM. The serum thus recovered was spread over several samples of 500µl and stored at -20°C to day of analysis. After thawing in an oven at 37°C for 10 min, serum samples were subjected to measurement by a semi automatic spectrophotometer (CYANplus ®) using commercial kits (Randox ®, UK) for biochemical parameters viz. cholesterol (CH200), triglycerides (TR210), BHB (RB1007), urea (UR107), albumin (AB 362) and calcium (CA590).

After quantification of milk production at peak, a sample of 250 ml from each cow was collected. After a manual homogenization, it was immediately transported to the laboratory in a cooler and analyzed. The determination of milk fat was made by the method of acid-butyrometric or GERBER. The density and temperature measurement were made using a thermo-lacto densitometer. The acidity of milk was expressed in degrees Doronic (°D) which was equivalent to a grade of 0.1 g of lactic acid per liter of milk.

The mean, standard deviation and standard error were calculated and the tests for normality (Kolmogorov-Smirnov) and homogeneity of variances (Levene's test) were performed for all parameters. A multiple correlation (Pearson test) was used to estimate the covariance between parameters and to determine how these were related to each other over time.

To estimate the effect of BCS at dry and its change in postpartum we used one way ANOVA. The type of analysis of variance was chosen depending on nature of variables. The kreskall-Wallis test was used in cases where the normality of data was not assured. The Fisher statistics was calculated on normal data and homogeneous variances. If these were heterogeneous Fischer test was replaced by Welsh statistic. The comparison between means was performed by the LSD test (least significant difference) in the case of homogeneous, variances and T2 Tahmane in the opposite case. All analyzes were performed by SPSS 18.

RESULTS

Evaluation of nutritional and biochemical status around calving: Changes in BCS and blood parameters are summarized in Table 1. The results show that only BCS and serum cholesterol were significantly different in pre and post calving. The BCS was significantly higher in pre calving (P<0.01). However, serum cholesterol was significantly lower in pre calving compared to postpartum (P<0.001). However, although the differences were not significant (P>0.05), triglycerides decreased slightly in postpartum, while BHB and urea increased.

Production and milk quality: In our study, Montbéliarde cows produced at sixth week of lactation (peak) 20±4 kg of milk with 3.17±0.72% of fat. Density and acidity were equivalent to 1.030 and 16.4°D, respectively.

Table 1: Pre and post calving variability of body condition score and blood parameters

Traits	Pre calving		Post calving		P Value
	Mean±SD	SE	Mean±SD	SE	
BCS (Points)	3.04±0.41	0.07	2.77±0.49	0.09	0.009
Energetic trait					
Glucose (mg/dl)	61±9	1.4	60±9	2.0	0.588
Triglycerides (mg/dl)	43.2±27.8	4.51	39.0±23.9	4.62	0.391
Cholesterol (mg/dl)	103.8±40.5	6.49	177.1±59.9	11.13	0.000
BHB (mmol/l)	1.08±0.38	0.068	1.39±1.00	0.22	0.538
Azote trait					
Urea (mg/dl)	30.22±12.81	2.05	34.70±18.97	3.58	0.384
Albumin (g/dl)	4.22±0.49	0.09	4.25±0.47	0.10	0.801
Mineral trait					
Calcium (mg/dl)	8.52±2.58	0.41	8.30±2.33	0.43	0.646

Table 2: Correlation between BCS, Blood biochemical traits and milk yield and quality

	BCS	Glucose	Cholesterol	TG	Urea	BHB
4 week before calving						
BCS		ns	ns	ns	ns	--.321*
Glucose			ns	ns	ns	ns
Cholesterol				ns	ns	--.308*
Triglycerides					ns	ns
Urea						ns
6 week after calving						
MY	ns	--.449*	ns	ns	ns	--.514*
MFat	ns	ns	ns	.681*	ns	.522*
BCS		ns	--.416*	ns	--.366*	--.487*
Glucose			ns	ns	ns	ns
Cholesterol				ns	.461*	ns
Triglycerides					--.419*	ns
Urea						ns
BC to PC Change						
MY	ns	ns	ns	ns	ns	.652**
MFat	ns	ns	ns	ns	ns	ns
BCS		ns	ns	ns	--.372*	ns
Glucose			ns	ns	ns	ns
Cholesterol				ns	ns	ns
Triglyceride					ns	ns
Urea						ns

Milk yield (MY) and milk fat (MFat) were only included in the model after calving; BCS= body condition score; BHB=ß-Hydoxybutyrate; TG=triglycerides; *significant correlation at P<0.05; BC=before calving; PC=post-calving.

Correlation analysis: Correlation analysis (Table 2) shows that in pre-calving, serum BHB in cows was negatively correlated with their BCS (r=-0.32; P<0.05) and cholesterol (r=-0.31; P<0.05). Indeed, obese cows exhibit low concentrations of BHB and cholesterol compared to lean. In post-calving, production level at peak evolved in the negative direction with postpartum blood glucose (r=-0.45; P<0.05) and BHB (r=-0.51; P<0.05). High-producing cows showed low level of BHB (<1.5mmol / l) or glucose (<60 mg/dl). However, milk fat increased with the level of milk production at peak (r=0.54; P<0.05), serum triglycerides (r=0.68; P<0.05), and BHB (r=0.52; P<0.05), and decreased significantly with milk density (r=0.51; P<0.05). Furthermore, postpartum BCS was strongly and negatively correlated with cholesterol (r=-0.42; P<0.05), urea (r=-0.37; P<0.05) and BHB (r=-0.49; P<0.05).

Effect of body condition around calving: Analysis of variance (Table 3) showed that the level of milk production was independent of BC at dry (P>0.05). However, fat content was high in thin and obese. For postpartum blood biochemistry, BC at dry affected significantly serum cholesterol level with a decreasing gradient from thin to obese cows (P<0.05). Serum triglycerides showed the opposite trend but the difference was non-significant. However, a significant effect of BC profiles on serum triglycerides, cholesterol and BHB (P<0.05) was noted (Table 4).

DISCUSSION

The present study aims to characterize the relationship between changes in cow's BC, blood biochemical parameters and the level of milk production and quality (milk fat) at peak of lactation. A sharp decrease in postpartum BCS was recorded compared to that at dry (10% of loss). Several authors reported this decrease but with different intensities (Singh *et al.,* 2009; Mouffok *et al.,* 2011). Indeed, Dillon *et al.* (2003) reported that the level of reserves mobilization was related to genetic merit and highly productive cows had a low BC in postpartum.

The effects of diet and BC change may occur at the biochemical level by changes in concentrations of blood metabolites. In the present study, blood glucose was relatively stable at around 60mg/dl according to observation of Melendez *et al.* (2007) in cattle and Pulina *et al.* (2012) in sheep. Kaewlamun *et al.* (2012) noted that glucose concentrations remained stable and increased slightly at calving reflecting an increase in gluconeogenesis in response to calving stress. However, other researchers reported that glucose concentrations were higher in dry cows (Singh *et al.,* 2009) and increased with food (Marongiu *et al.,* 2002). Cows in negative energy balance have low rates of glucose and high levels of BHB (Xia *et al.,* 2007).

In this study triglycerides were relatively higher at dry stage. Similar results were reported by Ling *et al.* (2003). Their high concentrations in postpartum promotes increased fat content in milk. However, the negative correlation of triglycerides with uremia level suggests that nitrogen supplementation especially in degradable form can reduce milk fat content. However, cholesterol was significantly higher in postpartum. At dry it was negatively related to BHB. Its high concentration indicates good energy nutrition (Civelek *et al.,* 2011). However, Ling *et al.* (2003) reported a strong negative correlation in dry cows between cholesterol and triglycerides concentration, this situation was reversed in postpartum. Analysis of variance indicated that in post-calving, cholesterol was lower in cows with average BCS without loss and increased with the level of BCS loss from dry to postpartum. This can probably be explained by its contribution in triglycerides transport mobilized by adipose tissue in early lactation (Ling *et al.,* 2003).

The β-hydroxybutyrate increased in postpartum, but the difference was non significant (P>0.05). The BHB is negatively correlated with food level and it therefore increases in cows fed a good diet in dry and lower quality in post partum (Stockdale, 2008). At dry BHB is negatively correlated with body condition and serum cholesterol (Mäntysaari *et al*., 1999). But dietary supplementation can reduce blood NEFA and BHB particularly in post-calving (Melendez *et al.,* 2007).

In the end it was the only parameter which changed from dry to postpartum that characterizes milk level production. Its positive correlation indicates that cows in good BCS at dry have the ability to mobilize stored fat in postpartum and can produce more milk.

Milk yield in lactation peak, estimated at 20±4 kg, appears independent to body condition at dry. These results are consistent with the observations of Jilek *et al.* (2008) and Roche (2007), who reported that only the postpartum BC affected milk production level. Mushtaq *et al.* (2012) report that milk yield was negatively correlated with post-partum BCS probably due to mobilization of body reserves especially in early lactation. In addition, Loker *et al.* (2012) noted that changes in BCS and milk yield were related physiologically, these changes may not occur in perfect synchrony. For them, as lactation progressed, lower production was associated with greater BCS. However, Singh *et al.* (2009) and Msangi *et al.* (2005) noted that milk yield in peak and duration of lactation in high producing were higher among those with better body condition at dry. Moreover, Moallem *et al.* (2004) reported that pre calving supplementation increased milk production in subsequent lactation by 2kg/d but also fat content (3g/l). However, post-partum supplementation can correct the negative energy balance, resulting in the low loss of BC and lower rates of BHB and NEFA (Wang *et al.,* 2009).

According to Wathes *et al.* (2007), milk yield was independent to nutritional and biochemical parameters during only the first two weeks post-calving but it was significantly higher in cows expressing high levels of BHB (mobilization) and urea (good nutrition) at the 4th week.

The fat content assessed as 32±7g/l seems to be positively related to serum triglycerides and BHB. The fat content is derived from the mobilization of lipids as triglycerides. These provide a substrate for the synthesis of BHB in the liver tissue from NEFA not completely oxidize, consequence of limit hepatic capacity to use all fatty acid result from accelerate mobilization (Xia *et al.,* 2007).

The results obtained in this research show a significant decrease in postpartum body condition score

Table 3: Milk yield and quality and post-calving blood traits according to pre calving BCS

BCS at calving	BC	Milk yield and quality			Post-partum blood biochemistry			
		MY (kg)	Fat (g/l)	D	BHB (mmol/l)	Triglycerides (mg/dl)	Cholesterol (mg/dl)	Glucose (mg/dl)
Low	2.64±0.04a	22.8±1.3	36.7±2.9a	1.028	1.73±0.38	33.5±13.2	219±27a	56.7±2.7
Medium	3.01±0.01b	19.3±1.0	26.2±2.1b	1.031	1.35±0.33	37.4±5.1	175±13ab	62.9±2.1
High	3.75±0.14c	20.8±0.3	31.0±2.3ab	1.030	0.77±0.19	47.9±12.2	135±13b	59.3±5.5

MY=Milk yield; Values bearing different letters in a column differ significantly (P<0.05).

Table 4: Milk yield and quality and post-calving blood traits according to BCS profile

Profiles	BCS BC	BCS AC	MY (kg)	MFat (g/l)	Post-partum blood biochemistry				
					Glucose (mg/dl)	BHB*(mmol/dl)	Triglycerides*(mg/dl)	Cholesterol*(mg/dl)	Urea (mg/dl)
HWL	3.8±0.6	3.7±0.3	20.1±1.3	35.0±1.0	64.4±14.0	0.48±0.2	54.4±12.6	106±7.6	20.8±16
HSL	3.6±0.1	2.8±0.3	20.8±1.0	29.0±2.8	52.8±6.3	0.92±0.4	40.5±42.9	164±11.6	33.5±19
LWL	3.0±0.1	2.9±0.1	20.9±2.5	25.0±6.6	60.6±6.1	1.08±0.1	28.2±11.0	194±44.8	33.0±17
LSL	2.8±0.2	2.4±0.3	20.3±5.1	32.3±12	60.9±9.5	1.95±0.1	42.8±27.3	192±72.7	41.3±22

HWL=High without loss; HSL=High with significant loss; LWL=Low without loss; LSL=Low with significant loss; BC=Before calving; AC=After calving; MY=Milk yield; MFat=Milk fat ; *Significant difference at P<0.05.

accompanied by an increase in cholesterol and BHB concentration. In pre-calving, BHB was negatively correlated with BCS and cholesterol. In postpartum, BCS seems negatively correlated with cholesterol, urea and BHB. However, the level of milk decreased significantly with high glucose and BHB. The fat content increased significantly with blood triglycerides and BHB concentration, indicating a high mobilization of body reserves used for the synthesis of milk fat.

Conclusion: On the basis of results of this study, it can be interpreted that BHB seems to be the best indicator of the nutritional status of dairy cows that determines their production level and quality.

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