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ENERGY INPUTS AND NEEDS: IMPACT ON MILK PRODUCTION AND BODY RESERVES IN DAIRY COWS

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ABSTRACT

Algeria is a major importer of milk and dairy cows, with the Holstein and Monbéliarde breeds being the most common. Adapting these cows to their new environment poses a significant challenge in maintaining their original performance. This research aims to determine how feed input and milk production relate to body condition score (BCS) and energy reserves. Over three lactation periods, two flocks of dairy cows, 20 Prim'Holstein (PH) and 20 Montbéliarde (MB), pregnant at 5.6 ± 0.4 (PH) and 5.5 ± 0.4 (MB) months, were monitored under the same rearing conditions. The staple diet consisted of barley silage, green clover, grain barley, and wheat bran, with concentrate consumed twice daily during the milking period. Throughout three lactation periods, the state of body reserves deteriorated gradually, reaching BCS values below 2. In the first lactation, milk production was 4,211 ± 340 kg for MB and 3,965 ± 328 kg for PH, 5,024 ± 360 kg (MB) and 4,660 ± 420 kg (PH) in the second lactation and 5,700 ± 530 kg (MB) and 5,180 ± 400 kg (PH) in the third lactation. During the first week of lactation, the energy needs coverage rates for PH and MB were only 70 % and 77 %, respectively, while on the 30th day they were 66 % and 74 %, respectively. The balance between needs and inputs is restored at 120 %, starting on the 90th day of lactation. This energy deficit was recurring in both breeds and occurred during subsequent lactation.

Key words: BCS; dry period; energy inputs; energy needs; lactation

INTRODUCTION

Milk plays an important role in the diet of Algerians and is consumed in large quantities. Due to low domestic production, Algeria has become one of the world's largest importers of milk and high-producing dairy cows [6]. A rich, balanced diet and other factors such as breed, husbandry, housing, and sanitary and hygienic control, are required for good milk production. Dairy cows require a nutritionally and qualitatively balanced feed ration adapted to and consistent with their physiological stages.

The peripartum period is a critical stage in a dairy cow's physiological cycle, characterized by specific needs, and strict adaptation of energy metabolism [15]. This critical period corresponds to two distinct physiological periods: the end of dry-off, when feed requirements are low, and the start of lactation when energy requirements are high. For high-producing cows, this invariably results in a negative energy balance [5]. Estimating body condition scores is useful for evaluating and correcting dairy cow energy input [24]. It remains a good indicator for judging the animal's nutritional status, allowing us to address specific deficiencies and improve cow performance.

This study aimed to determine the relationship between feed input, milk production, energy balance, and body condition score in imported Holstein and Montbeliarde cows with poor milk production performance.

MATERIALS AND METHODS

Study site and animals

This study was conducted at the Technical Institute for Livestock in the Algerian wilaya of Guelma. This region is distinguished by lush vegetation and a sub-humid climate, with mild winters and hot summers. The farm was visited several times per month from October 2021 to November 2022. The concrete floor of the 50-cow barn was covered with straw bedding that was replaced every three days. Regular maintenance by qualified personnel ensured stable hygiene, ventilation, and animal cleanliness. Our sample included 20 Prim'Holstein (PH) imported from Europe and 20 Montbeliarde (MB), Algeria's two most common dairy cow breeds. These cows were stanchion-housed in the same barn, with the same rearing conditions and a 1/2-hectare exercise area. The age of cows was 18.6 ± 0.9 months for PH and 26.5 ± 0.9 months for MB, 5.6 ± 0.4 months for PH and 5.5 ± 0.4 months for the MB, and 5.6 ± 0.4 months for PH and 5.5 ± 0.4 months for MB. At the start of the study, average body condition scores for PH heifers were 3.0 ± 0.2 and 3.2 ± 0.2 for MB heifers.

The cows were fed a basic ration of barley silage, green clover, grain barley, and wheat bran, with concentrate consumed at a rate of 3 to 4 kg per cow and day during milking. The dry cows were only fed vetch-oat hay or cereal straw. Based on quantities distributed and refusals, forage and concentrate dry matter (DM) consumption levels were calculated at D30 and D60 lactation.

Body condition score

Body condition score (BCS) was determined using the standardized scoring grids [35, 38], adapted for Prim'Holstein and Montbéliarde cows [4]. In addition, chest circumference measurement to estimate body weight (BW) was carried out after successive calvings of each cow. This visual rating is assigned by positioning oneself to the right, front and rear of the animal and can be consolidated by touching the animal. The front score is based on the spine-hip connection, the tip of the hips and the transverse processes, while the rear score is based on the caudal fossa, the tip of the buttocks and the tail vertebrae. BCS was recorded at calving, D30 and D60, and dry-off. To ensure consistency in scoring, all cows were observed in the same position.

Milk production

Milk production records were used to determine the initial and maximum production. Calving conditions, as well as any pathological conditions, were recorded. The first control was established on D4, D5 and D6, and the maximum milk production (MP max) was established from controls on D1 of weeks 7, 8 and 9.

Energy balance

The body weight of cows was used to calculate energy and nitrogen requirements for maintenance and average milk production. Average DM consumption and average energy-protein concentrations of rations consumed per control phase were used to calculate the inputs.

Statistical analysis

The collected data were analysed using SPSS software 26. The effect of the factor "breed" was determined by analysis of variance ANOVA where the "Fisher" test was applied to compare the two breeds with $P < 0.05$ as the level of significance.

RESULTS

Except for wheat bran, all feedstuffs were produced on the farm. During the monitoring period, the same forage calendar, consisting of winter forages, was repeated each year, resulting in three feeding periods with typical basic rations. Between September and December, the first ration

(R1) was based on barley silage (BS) and vetch-oat hay (VOH), or cereal straw (CS), the second ration (R2) was based on green clover (GC) and VOH, or CS, and the third ration (R3) was based on VOH, or CS between June and August (Table 1). At the milking parlour, concentrate feedings of crushed barley (CB) and wheat bran (WB) were administered twice daily. Dry matter input (DMI) was reduced at the start of lactation and increased during the subsequent lactation period up to D60. When the two breeds were compared, the MB consumed more DM than the PH, especially during the first lactation ($P < 0.05$), and subsequent lactation period. The energy balance was negative even after D60 compared to the average energy needs at 30 and D60 (Table 2).

Table 1. Dietary values of farm feeds

Feed	Values per kg DM						Availability period	Total
	UFL	UEL	PDIE	PDIN	P	Ca		
BS	1.12	0.75	80	69	3	2	Sept-Oct-Nov-Dec	R1
GC	0.89	0.93	97	156	13.7	3	Jan-Feb-March-Apr-May	R2
VOH	1.1	0.68	70	78	2.6	6	All year round	R1 R2 R3
CS	1.45	0.42	44	22	1	2	July-Aug-Sep	R3
CB	-	1.09	101	79	4	1	All year round	R1 R2 R3
WB	-	0.92	87	107	11.2	1.6	All year round	R1 R2 R3

(BS = barley silage; GC = green clover; VOH = vetch oat hay; CS = cereal straw; CB = grain barley; WB = wheat bran; UFL = milk fodder unit; UEL = milk energy unit; PDIN = intestinal digestible proteins enabled by nitrogen; PDIE = intestinal digestible proteins enabled by energy; R = ration

Table 2. Energy input (UFL) by period (30 and D60), breed and lactation period and DM consumption (kg.day^{-1})

State	Breed	Lactation period					
		L1	UFL	L2	UFL	L3	UFL
30	PH	9.5 ± 2.2a	7 ± 1.2	11 ± 3b	8 ± 1	11.6 ± 2.3b	8 ±1.4
	MB	10.4 ± 1.4b	8 ± 0.6	12.5 ±1.7bc	8.6 ± 0.4	12 ± 2b	8 ±1.4
60	PH	12 ± 2a	10 ± 0.8	14.5 ± 3b	10 ± 1.2	14.5 ± 2b	10 ± 0.8
	MB	14.5 ± 1.6b	11 ± 1	15.5 ± 2.6	12 ± 1.4	15b ±1.4b	12 ± 0.6

Results in the same row and the same column followed by distinct letters are different at the threshold of $P < 0.05$; L1, L2, L3: first, second and third lactation periods; PH = Prim'Holstein; MB = Montbéliarde; UFL= milk fodder unit

Table 3. Average energy and protein concentrations of rations consumed by period
(first control at D30, D60 and D90), breed (PH, MB) and lactation (L) period.

Lactation period		L1			L2			L3		
State	Breed	UFL	PDIE	PDIN	UFL	PDIE	PDIN	UFL	PDIE	PDIN
First control	PH	0.80	83	78	0.78	86	78	0.81	87	132
	MB	0.78	84	77	0.78	83	79	0.80	82	118
D30	PH	0.74	87	78	0.73	85	81	0.69	85	126
	MB	0.77	85	81	0.69	86	82	0.67	88	135
D60	PH	0.83	88	78	0.69	85	125	0.69	83	123
	MB	0.76	87	83	0.77	90	135	0.80	87	125
D90	PH	0.83	85	129	0.81	85	129	0.81	85	129
	MB	0.82	88	135	0.79	88	135	0.82	87	132

PH = Prim'Holstein; MB = Montbéliarde; UFL=milk fodder unit; PDIN =intestinal digestible proteins enabled by nitrogen; PDIE= intestinal digestible proteins enabled by energy

Changes in nutritional needs and input

Energy balance

The calculation of energy and nitrogen requirements was based on the estimation of body weight for maintenance, and the average milk production. Intakes are calculated from the average DM consumption and the average protein energy concentrations of the rations consumed per control phase (Table 3).

The energy input was insufficient (Table 4). The energy input/expenditure imbalance persisted until D60, when it recovered to become positive.

The coverage rates of energy expenditure were only 70 % for PH and 77 % for MB during the first week of lactation, then dropped to 66 % and 74 %, respectively, by D30. It was not until the D90 of lactation that the balance between needs and input was restored, with an average rate of 120 %, to more than cover the energy expenditure. This energy deficit was recurring in both breeds, and reappeared in the subsequent lactation period. In comparison, MB has always consumed more energy than PH.

Table 4. Rate (%C) of energy needs (B) and input (A) by period
(first control, D30, D60 and D90), breed (PH, MB) and lactation (L) period.

Lactation period		L1			L2			L3		
State	Breed	B	A	%C	B	A	%C	B	A	%C
First C	PH	8	5.6	70	9	6.2	69	8.9	6.5	73
	MB	8.6	6.6	77	9	7	78	9.8	7.2	74
D30	PH	10.7	7	66	11.2	8	72	10.9	8	73
	MB	10.8	8	74	11	8.6	78	11.4	8	70
D60	PH*	10.4	10	96	10.8	10	93	10.5	10	95
	MB	10.8	11	102	11	12	109	11.9	12	101
90th	PH	9.6	11.6	120	10	12.1	121	9.5	11.6	122
	MB	10	12. 3	123	10.2	12.6	123	11	12.5	113

Table 5. PDI needs (B) and PDIE and PDIN inputs in g/cow/day by period
(first control, D30, D60 and D90), breed (PH, MB) and lactation (L) period.

Lactation period		L1			L2			L3		
		A		B	A		B	A		B
State	Breed	PDIE	PDIN	PDI	PDIE	PDIN	PDI	PDIE	PDIN	PDI
First C	PH	581	437	780	688	624	876	696	1056	861
	MB	714	508	876	747	711	900	738	1062	986
D30	PH	827	546	1068	935	891	1111	986	1462	1087
	MB	884	648	1116	1088	1025	1116	1056	1620	1164
D60	PH	1056	780	1034	1233	1871	1068	1204	1784	1039
	MB	1262	913	1116	1364	2093	1116	1305	1875	1221
D90	PH	1190	1496	934	1275	1935	950	1275	1935	900
	MB	1320	1701	1016	1408	2160	1024	1392	2112	1100

Table 6. Average nitrogen imbalance in g per cow and day (D) for PDIE (e) and PDIN (n), cumulated (DC) at D30, D60 and D90), by breed (PH, MB) and lactation (L) period.

Lactation period		L1			L2			L3		
State	Breed	D(g)	DC(kg)	R*	D(g)	DC(kg)	R*	D(g)	DC(kg)	R*
D30	PH	522(n)	15.6	40	220(n)	6.6	6	101	3	-59
	MB	468(n)	14	30	91(n)	2.7	7	108	3.2	-71
D60	PH	254(n)	22.2	28	+164(e)	-	-64	-165	-	-58
	MB	203(n)	20	32	+248(e)	-	-61	-84	-	-48
D90	PH	+256(e)	-	-26	+325(e)	-	-55	375	-	-57
	MB	+304(e)	-	-30	+384(e)	-	-60	292	-	-58

R* = PDIE-PDIN/UFL ratio

Energy and protein balance

Tables 5 and 6 show the protein inputs. A comparison of average quantities between needs (B) and inputs (A), regardless of breed or lactation period, revealed that protein inputs (PDI) were lower than needs, particularly during the 30 days of lactation.

At the start of lactation, cumulative deficits between protein needs and protein input (Tables 5 and 6) were significant, ranging from 14 kg to 15.6 kg of PDI at D30 and from 20 kg to 22.2 kg at D60. They became positive when the balance between needs and inputs was restored at D90 in the first lactation and D30 in the second and third lactation periods. In terms of quality, the ration's degradable nitrogen input, as measured by the PDIE-PDIN/UFL ratio (R*), was above the required standard, which must not exceed a score of 4 in the first lactation until D60 and only until D30 in the second and third lactation.

Evolution of body weight and reserves

Body weight (BW) was higher ($P < 0.05$) in MB (580 ± 45 kg) than in PH (510 ± 37 kg) at first calving. During the second and third calving, it increased for both breeds, reaching 607 ± 42 kg and 620 ± 28 kg for MB and 555 ± 49 kg and 580 ± 33 kg for PH, respectively. Table 7 displays the average results for BCS evolution. The mobilization of body reserves was 0.5 (PH) and 0.4 (MB) during the first 30 days of first lactation and was not significant, but at D60, PH mobilized more reserves than MB (respectively, 0.8 and 0.6 points ($P < 0.05$). At dry-off in the first lactation, reserves in both breeds had not been fully replenished (BCS: MB 2.6 and PH 2.4). Fat mobilization was similar by D30 (average 0.6) during the second and third lactation periods; both breeds reached and maintained the 2-point threshold until D60. The return to the level of reserves at calving was never achieved in either breed in all three lactation periods.

Table 7. Variations in body weight (BW), body condition score (BCS) at the main physiological phases of the 3 lactation (L) periods.

State	Breed	Lactation period		
		L1	L2	L3
BW at calving	PH	510 ± 45a	555 ± 49	580 ± 33
	MB	580 ± 38b	607 ± 42	620 ± 28
BCS V	PH	2.8 ± 0.2a	2.4 ± 0.2	2.0 ± 0.2
	MB	3.0 ± 0.2b	2.6 ± 0.3	2.4 ± 0.2
BCS 30	PH	2.3 ± 0.2a	1.8 ± 0.2	1.6 ± 0.3
	MB	2.6 ± 0.3a	2 ± 0.3	1.8 ± 0.3
BCS 60	PH	2 ± 0.2a	1.8 ± 0.2	1.5 ± 0.2
	MB	2.4 ± 0.3b	2 ± 0.3	1.8 ± 0.2
BCS DO	PH	2.4 ± 0.2a	2.1 ± 0.3	-
	MB	2.6 ± 0.3b	2.3 ± 0.2	-

Results in the same row and column followed by distinct letters differed at the $P < 0.05$ threshold expressed for loss in BCS versus BCS V.

DISCUSSION

Changes in nutritional needs and input

In dairy farming, energy deficiency (ED) occurs when the energy input of the ration is less than the animal's needs. It is caused by the animal's specific physiological status (especially at the start of lactation) and feeding practices linked to the farmer's objectives (rationing) and/or farm hazards (food shortage) [20]. A discrepancy between the quantity of MSI and needs is observed as early as the last month of gestation: ingestion capacity tends to fall in the last days of gestation, while needs only increase. The dry matter consumed in the last three weeks before calving decreased by 32 %. More specifically, 89 % of this decrease occurs during the final week of pregnancy [22, 25]. Feeds given at the start of lactation have a low energy density (0.7 to 0.8 UFL.kg^{-1} DM) and cannot compensate for the decrease in MSI needed to meet needs during this time.

The average energy density of the rations consumed is significantly lower than the 0.95 UFL.kg^{-1} DM usually sought in early lactation. This is difficult to achieve because very good forages rarely exceed 0.9 UFL UFL.kg^{-1} DM, whereas common energy concentrates like cereals rarely exceed 1.2 UFL UFL.kg^{-1} DM [17]. Protein and energy requirements doubled after calving, but the amount of dry matter ingested per day only increased by 25 % in the first 30 days and by 60 % by D60. This finding is consistent with the findings of H a y i r l i et al. [25], who revealed that the maximum IMS occurs 2 to 4 months after calving. Dry matter input (DMI) is one of the peripartum period's challenges for limiting the energy deficit's extent. The goal is to have a dairy cow with the highest input capacity possible [26]. Feeding during the dry period modulates the amount of MSI in our study by focusing on dry forages such as vetch-oat hay (VAM) or cereal straw. This reduction in feed input can reach 30 % in the days leading up to parturition [22, 36, 37] and then gradually increase [2], peaking between 10 and 12 weeks of lactation [18].

Evolution of body reserves

BCS at calving is 3 points for MB and 2.8 points for PH, both below the recommended levels. The goal is to have a dry-off score of 3.5 points and keep it stable until calving [15].

Some authors, however, suggest a slightly lower score of 3.25 points at calving [38, 41]. If a cow calves too thin (BCS < 3 points) and mobilizes 3 to 4 times less of her reserves [16], the deficit will not be made up, preventing the body from mobilizing adipose tissue. We frequently observe an exacerbated imbalance between entrances (ingestion) and outlets (production) at this stage. As a result, the difficulty in adapting regulatory mechanisms can result in disorders such as steatosis and ketosis. The amount of dry matter ingested at the start of lactation decreases with calving body condition [7], with a proportional relationship for calving body condition ranging from 1.6 to 3.8 (scale 1 to 5). Between two groups of cows with a one-point difference in BCS, the difference in dry matter input per day is 1.3 kg; a cow with a 3.5-point score at calving consumes 1.3 kg less per day than a cow with a 2.5-point score. An average BCS of 3.5 to 3.2 is accepted for first calving [16, 38, 41]. The energy deficit, which lasts until D60 in all lactation periods, explains the low PL in both breeds in relation to their potential.

W a l t n e r et al. [42] reported a 322 kg drop in milk in the D90 following the start of lactation due to a 3 to 2-point decrease in BCS at first calving. During the first phase, there was a significant decrease in body condition, with a loss of 0.5 points, which is consistent with the findings of M o u f f o k et al. [33], who found an average decrease of 2.8 to 2.5 points during the first 60 days of lactation. This loss of body condition is caused by the intense use of body reserves following calving. During the first 60 days after calving, lipid mobilization ranged from 20 to 70 kg [34]. The reasons for fat reserve mobilization, and thus the decrease in body condition observed at the start of lactation, are linked to a negative energy balance. After calving, average milk production peaks, while energy consumption remains low compared to the amount required for milk production.

The second phase of the body condition curve occurs after 60 postpartum days, with an increase in BCS [14]. This reflects the reconstitution of the animal's energy reserves, which is linked to the animal's ability to ingest dry matter and activate lipogenesis at the expense of lipolysis, which decreases. Excess nutrients are thus absorbed and stored in reserve tissues, increasing the body condition score. Body condition score returns to the same level as at calving at the end of lactation [42], which was not the case in our study, where the cows' BCS never returned to the fattening level at calving. According to W a l t n e r et al. [42], Holstein cows in Washington, USA, reach their lowest body condition level 60 days after calving after three stages of lactation.

Milk production

In the first, second, and third lactation periods, Montbeliarde cows calving late at 32 months produced more milk than PH cows calving early at 24 months: 246 kg, 364 kg, and 520 kg of milk, respectively. These findings are consistent with those of A b e n i et al. [1], D o b o s et al. [12], F i s h e r et al. [19], and L i n et al. [32], who found that late calving increases PL in primiparous cows, regardless of breed or feeding strategy.

These increases range from +34 kg to +70 kg of milk per 10 kg difference in live weight at first calving, while milk production varies quantitatively and qualitatively depending on feeding strategy and cow parity [21]. The additional growth needs for body development compete with those of lactation for PH in early calving at 24 months [30], which is explained by the higher mobilization of reserves in this breed in first lactation. The higher PL levels in MB are due to its higher ingestion capacity, which is associated with age [27, 28] and live weight at first calving [30, 40]. Low PL in PH and MB during the first lactation is associated with low body mobilization, resulting in a 0.5-point loss in BCS. The significant growth that competes with lactation needs was 45 kg in PH in the first lactation and 25 kg in the second lactation [30]. MB gained 27 kg during the first lactation and 13 kg during the second [30].

Under the same dietary conditions and amid an energy deficit, PH's negative effects are more intense than MB, as evidenced by Cutillic et al. [11]. findings. An energy deficit is unavoidable and physiological at the start of lactation. Observation of energy need coverage rates reveals discrepancies of around 30 % and 26 % between needs and inputs at the start of the first lactation for PH and MB, respectively. This pattern recurs in both breeds' subsequent lactation periods. These findings are consistent with observations of Journet [29] that the energy and nitrogen deficiency risk in high-producing cows is greatest at the start of lactation (during the first month) when needs are highest and ingestion capacity is lowest. Drackley [13] reported that net energy needs in early lactation exceed feed input by 26 % and 25 %, respectively. The same author also claimed that the udder consumes 97 % and 83 % of net energy, respectively, leaving little for maintenance and growth. It should be noted that even minor pathology can increase and perpetuate an energy deficit around calving [13, 29].

The recovery of the energy balance after 60 days of lactation is consistent with the findings of several authors, who found that it becomes positive again at around 8 weeks in primiparous cows and 12 weeks in multiparous cows [3, 8]. Unlike energy reserves, protein reserves are scarce in early lactation and have little bearing on milk production. During involution, the majority of these reserves are supplied by uterine muscle. Skeletal muscle protein mobilization remains tolerable if a cumulative PDI deficit of more than 10 kg is not exceeded during the first month of lactation, corresponding to approximately 200 kg of milk. This tolerated level of PDI deficit is significantly lower than the results obtained in our study, which were mostly around 15 kg for all breeds and lactation periods combined. This value is much lower than the energy deficit tolerated by high-potential cows.

The average protein concentration (g PDI: kg DM) of rations distributed at the start and middle of lactation (< 100 $g.kg^{-1}$ DM) is lower than that recommended for complete rations, which recommend a PDI content of 120 $g.kg^{-1}$ DM at the start of lactation, compared to 110 $g.kg^{-1}$ DM for cows in mid-lactation [9]. When the nitrogen deficit concerns PDI input, i.e., a lack of absorbed amino acids, we observe a reduction in milk production at the start of lactation, which can explain a lower utilization of energy reserves. The degradable nitrogen deficit (PDIN input less than PDIE) observed in the first and second lactation limits the efficiency of microbial digestion and leads to a decrease in milk production due to reduced input. This deficiency is more pronounced in dry-off rations, where forages contain little degradable nitrogen. The ruminal flora is less tolerant of rapid transitions, and lower ingestion capacity at the start of lactation results in lower milk production [10, 23].

During the third lactation, however, there is an excess of degradable nitrogen (PDIN input greater than PDIE input). Excess degradable nitrogen places additional demands on the liver, in addition to the significant postpartum gluconeogenesis and potential steatosis, because ammonia absorbed from the rumen activates hepatic detoxification processes; however, converting ammonia to urea is energy-intensive, which is undesirable in times of energy scarcity. Using protected proteins in the form of tanned oilcake increases the nitrogen level of the ration while limiting an excess of degradable nitrogen. This type of ratio also has the advantage of optimizing peak lactation, but it may have secondary effects on the energy deficit and, thus, the risk of ketosis because the increase in production is not offset by an increase in appetite [17].

CONCLUSIONS

Given the energy deficit, MB and PH performed below their milk production and reproduction potential over three lactation periods. Despite the prolonged nutrient deficit at the start of lactation, Montbeliarde cows, aged on average 7.9 ± 0.9 months, outperformed Prim'Holstein cows in milk production and reproductive performance. Both breeds' body reserves deteriorated gradually over the three lactation periods, reaching critical levels at 60 days of lactation. Montbeliarde cows, on the other hand, have always had higher reserves than Prim'Holstein. The level of postpartum energy deficit in breeding females is a major risk factor for performance deterioration in dairy cows, particularly in Prim'Holstein and Montbéliarde. The severity and duration of this deficit after calving are determined by milk production, body reserves at the time of calving, and feed input.

The body condition score method for assessing energy imbalance reveals that an exaggerated loss of physiological condition during the postpartum period is detrimental to performance. Regular estimation of body condition scores to generate profiles is an important tool in both an individual approach for detecting subjects at risk and a herd-level approach for evaluating and correcting the energy feed distributed to dairy cows. Breed, age at the introduction into production, age at first calving, feeding conditions and reproductive control, and the balance between production and expenditure at a given age must all be considered when importing pregnant heifers.

REFERENCES

1. **Abeni, F. L., Calamari, L., Stefanini, L., Pirlo, G., 2000:** Effects of daily gain in pre- and post-pubertal replacement dairy heifers on body condition score, body size, metabolic profile, and future milk production. *J. Dairy Sci.,* 83, 7, 1468–1478. DOI: 10.3168/jds.S0022-0302(00)75019-3.
2. **Aubadie-Ladrix, M., 2011:** La cétose de la vache laitière. *Bull. GTV*, 59, 79–88.
3. **Bareille, S., Bareille, N., 1995:** La cétose des ruminants (Maladie métaboliquedes ruminants). *Point Vet*., 27, 727–738.
4. **Bazin, S., 1984:** *Grille de notation de l'état d'engraissement des vaches pie noires*. ITERB-RNED, Paris, 31 pp.
5. **Beam, S. W., Butler, W. R., 1998:** Energy balance metabolic hormones and early post-partum follicular development in dairy cows fed prilled lipid. *J. Dairy Sci*., 81, 1, 121–131. DOI: 10.3168/jds.S0022-0302(98)75559-6.
6. **Benghida, T., 2021:** *Situation de la Filière lait en Algérie.* Mémoire en vue de l'obtention du diplôme de Master. Université 8 Mai 1945, Guelma, 1 p.
7. **Broster, W. H., Broster, V. J., 1998:** Body score of dairy cows. *J. Dairy Sci.,* 65, 1, 155–173. DOI: 10.1017/s0022029997002550.
8. **Butler, W. R., Smith, R. D., 1989:** Inter relationships between energy balance and post partum reproductive function in dairy cattle. *J. Dairy Sci.,* 72, 3, 767–783. DOI: 10.3168/jds.S0022.0302(89)79169-4.
9. **Chenais, F. P., Augeard, P., Bazin, S., Martial, J. P., Masson, D., 1990:** Les rations complètes à base d'ensilage de maïs: atouts et mise en œuvre. *Collection « le point sur »*, ITEB, 149 rue de Bercy, Paris, 48 pp.
10. **Chew, B. P., Murdock, F. R., Riley, R. E., Hillers, J. K., 1984:** Influence of prepartum dietary crude protein on growth hormone, insulin, reproduction and lactation of dairy cows. *J. Dairy Sci*., 67, 2, 270–275. DOI: 10.3168/jds.S0022-0302(84)81299-0.
11. **Cutullic, E., Delaby, L., Gallard, Y., Disenhaus, C., 2011:** Dairy cows' reproductive response to feeding level differs according to the reproductive stage and the breed. *Animal*, 5, 731–740. DOI: 10.1017/S1751731110002235.
12. **Dobos, R. C., Nandra, K. S., Riley, K., Fulkerson, W. J., Alford, A., Lean, I. J., 2004:** Effects of age and live weight at first calving on first lactation milk, protein and fat yield of Friesian heifers. *Aust. J. Exp. Agric*., 44, 969–974.
13. **Drackley, J. K., 1999:** Biology of dairy cows during the transition period: The final frontier? *J. Dairy Sci.,* 82, 11, 2259–2273. DOI: 10.3168/jds.S0022-0302(99)75474-3.
14. **Drame, E. D., Hanzen, C., Houtain, J. Y., Laurent, Y., Fall, A., 1999:** Profil de l'état corporel au cours du post partum chez la vache laitière. *Ann. Med. Vét*., 143, 265–270.
15. **Duffield, T. F., Sandals, D., Leslie, K. E., Lissemore, K., McBrided, B. W., Lumsden, J. H., Dick, P., Bagg, R., 1998:** Efficacity of monensin for the prevention of subclinical ketosis in lactating dairy cows. *J. Dairy Sci.,* 81, 11, 2866–2873. DOI: 10.3168/jds.S0022-0302(98)75846-1.
16. **Enjalbert, F., 1998:** Contraintes nutritionnelles et métaboliques pour le rationnement en peripartum. *Le Nouveau Praticien*., 59–68.
17. **Enjalbert, F., 2003:** Les contraintes nutritionnelles autour du vêlage. *Point Vet*., 236, 40–44.
18. **Ferré, D., Aubadie-Ladrix, M., 2004:** *La cétose et la stéatose de la vache laitière: importance économique, phsiopathologie, conséquences pathologiques*. *Journées Nationales GTV*. 443–454.
19. **Fisher, L. J., Hall, J. W., Jones, S. E., 1983:** Weight and age at calving and weight change related to first lactation milk yield. *J. Dairy Sci.,* 66, 10, 21–67. DOI: 10.3168/jds.S0022-0302(83)82064-5.
20. **Gelé, M., Blanchet, M., Laigle, A., Woiltock, A., Jurquet, J., Le Cozler, Y.,Guinard-Flament, J., 2020:** Déficit énergétique chez la vache laitière: Indicateurs utilisés et niveau de sensibilisation des éleveurs et accompagnants techniques. *25. Rencontres Recherches Ruminants* (*hal-03223194)*, En ligne, France, 195–197.
21. **Gelé, M., Delaby, L., Leurent-Colette, S., 2019:** Composition fine du lait en lien avec le type de vaches laitières et leur conduite alimentaire à l'échelle de la lactation. *Fourrages*, 239, 203–206.
22. **Goff, J., Horst, R. L., 1997:** Physiological changes at parturition and their relationship to metabolic disorders. *J. Dairy Sci.,* 80, 7, 1260–1268. DOI: 10.3168/jds.S0022-0302(97)76055-7.

23. **Greenfield, R. B., Cecava, M. J., Johnson., T. R., Donkin, S. S., 2000:** Impact of dietary protein amount and rumen undegradability on intake, peripartum liver triglyceride, plasma metabolites, and milk production in transition dairy cattle. *J. Dairy Sci.,* 83, 4, 703–710. DOI: 10.3168/jds.S0022-0302(00)74932-0.
24. **Hady, P. J., Domecq, J. J., Kaneene, J. B., 1994:** Frequency and precision of body condition scoring in dairy cattle. *J. Dairy Sci.,* 77, 6, 1543–1547. DOI: 10.3168/jds.S0022-0302(94)77095-8.
25. **Hayirli, A., Grummer, R. R., Nordheim, E. V., Crump, P. M., 2002:** Animal and dietary factors affecting feed intake during the pre-fresh transition period in Holsteins. *J. Dairy Sci.,* 85, 12, 3430–3443. DOI: 10.3168/jds.S0022-0302(02)74431-7.
26. **Hayirli, A., Keisler, D. H., Doepel, L., Petit, H., 2011:** Peripartum responses of dairy cows to prepartal feeding level and dietary fatty acid source. *J. Dairy Sci.,* 94, 2, 917–930. DOI: 10.3168/jds.2010-3674.
27. **Hazel, A. R., Heins, B. J., Seykora, A. J., Hansen, L. B., 2013:** Montbeliarde-sired crossbred compared with pure Holsteins for dry matter intake, production, and body traits during the first 150 days of first lactation. *J. Dairy Sci.,* 96, 3,1915–1923. DOI: 10.3168/jds.2012-5667.
28. **Heins, B. J., Hansen, L. B., Seykora, A. J., Hazel, A. R., Johnson, D. G., Linn, J. G., 2008:** Crossbreds of Jersey and Holstein compared with pure Holsteins for body weight, body condition score, dry matter in take, and feed efficiency during the first one hundred fifty days of traits and body and udder measurements in Holstein heifers. *J. Dairy Sci.,* 91, 9, 3716–3722. DOI: 10.3168/jds.2008-1094.
29. **Ingvartsen, K. L., Andersen, J. B., 2000:** Integration of metabolism and in take regulation: a review focusing on periparturient animals. *J. Dairy Sci.,* 83, 7, 1573–1597. DOI: 10.3168/jds.S0022-0302(00)75029-6.
30. **Journet, M., 1981:** Conduite au pâturage des troupeaux laitiers à assez haut niveau de production. *Fourrages*, 85, 95–111.
31. **Le Cozler, Y., Peccatte, J. R., Porhie, J. Y., Brunschwig, P., Disenhaus, C., 2009:** Pratiques d'élevages et performances des génisses laitières: état des connaissances et perspectives. *Inra Productions Animales*, 22, 303–316. DOI: 10.20870/productions-animales.2009.22.4.3356.
32. **Lin, C. Y., Lee, A. J., Mcallister, T. R, Batra, G. L., Roy, J. A., Vesely, J. A., et al., 1987:** Inter correlations among milk production traits and body and udder measurements in Holstein heifers. *J. Dairy Sci.,* 70, 11, 2385–93.
33. **Mouffok, C. E., Semar, L., Madani, T., Debeche, H., Belkasmi, F., 2013:** Impact of pre and post-calving body condition score change on reproduction traits of Montbeliarde cows in Algerian semi-arid area. *J. Anim. Plant Sci.*, 23, 1253–1263.
34. **Otto, K. L., Ferguson, J. D., Fox, D. G., 1991:** Relationship between condition score and composition of ninth to eleventh rib tissue in Holstein dairy cows. *J. Dairy Sci.,*74, 3, 852–859. DOI: 10.1088/1755-1315/1060/1/012069.
35. **Ponsart, C., Dubois, P., Charbonnier, G., Leger, T., Freret, S., Humblot, P., 2007:** *Evolution de l'état corporel entre 0 et 120 jours de lactation et reproduction des vaches laitières hautes productrices. Journées nationales des GTV.* Nantes, 347–356.
36. **Rousseau, C., 2013:** Alimentation des vaches taries: les bases théoriques. *Point Vet*., 44, 86–92.
37. **Salat, O., 2012:** La stéatose hépatique. Affections hépatiques chez les bovins avec un focus sur les méthodes diagnostiques. *La Dépêche Technique*,130, 3–7.
38. **Seifi, H. A., LeBlanc, S., Leslie, K. E., Duffield, T. F., 2011:** Metabolic predictors of post-partum disease and culling risk in dairy cattle. *Vet. J.*, 188, 216–220. DOI: 10.1016/j.tvjl.2010.04.007.
39. **Vasseur, E., Gibbons, J., Rushen, J., de Passillé, A. M.., 2013:** Development and implementation of a training program to ensure high repeatability of body condition score of dairy cow in animal welfare assessments. *J. Dairy Sci.,* 96, 7, 4725–4737. DOI: 10.3168/jds.2012-6359.
40. **Veerkamp, R. F., Oldenbroek, J. K., Van Der Gaast, H. J., Van Der Werf, J. H. J., 2000:** Genetic correlation between days until start of luteal activity and milk yield, energy balance and live weights. *J. Dairy Sci.,* 83, 3, 577–583. DOI: 10.3168/jds.S0022-0302(00)74917-4.
41. **Walsh, S., Buckley, F., Pierce, K., Byrne, N., Patton, J., Dillon, P., 2008:** Effects of breed and feeding system on milk production, body weight, body condition score, reproductive performance, and postpartum ovarian function. *J. Dairy Sci.,* 91, 11, 4401–4413. DOI: 10.3168/jds.2007-0818.
42. **Waltner, S. S., Mc Namara, J. P., Hillers, J. K., 1993:** Relationship of body condition score to production variables in high producing Holstein dairy cattle. *J. Dairy Sci.,* 76, 11, 3410–3419. DOI: 10.3168/jds.S0022-0302(93)77679-1.

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