Egyptian Journal of Veterinary Sciences
https://ejvs.journals.ekb.eg/

Metabolic Profiling 10 Weeks Before Until 25 Weeks After Parturition in Dairy Cows

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Abstract

THE EXPERIMENT was planned to monitor the metabolic status of the dairy cows from 10 weeks before until 25 weeks after parturition. For this purpose, 10 clinically healthy multiparous pregnant were used. Twelve blood samples and subsequently sera were collected from each cow as follows: before expected parturition at -10wk, -7wk, and -3wk, within 12 hours of parturition, and after parturition at weeks 1, 2, 3, 4, 5, 10, 15 and 25. Compared to values at 10wk before parturition, the BW increased significantly at 3wk. However, BW decreased significantly at -10wk and at -3wk. The AST activity increased significantly at parturition compared to -10wk activity; it remained high through weeks 1,2,3,4 and 10 after parturition. The total bilirubin concentration increased gradually starting from -3wk before the expected parturition until 1wk after parturition, then decreased gradually until 15wk after parturition with a statistical difference compared to values at parturition. Starting from -10wk before parturition, total cholesterol concentration decreased significantly until birth then increased gradually until 10wk after parturition. The concentration of non-esterified fatty acids increased substantially at birth and 1 week after parturition compared to tested weeks before birth. The levels were also high at 4wk, 5wk, and 10wk after birth compared to tested weeks before parturition. The triglyceride concentration increased significantly at -7wk and -3wk compared to -10wk before parturition. In conclusion, the metabolic profiling test is a prognostic indicator of the healthy condition of dairy cows during a long period that extends almost 250 days of different reproductive phases.

Keywords: Cattle, Metabolic profile test, Physiology, Pregnancy, Reproduction.

Introduction

To monitor dairy animals for abnormalities during different reproductive stages, a metabolic profile test (MPT) is usually carried out [1]. By this methodology, the supervising veterinarian can evaluate the following nutritional regime and also can predict some metabolic disorders before their actual appearance [2-5]. In dairy cows, the practicability of MPT was evaluated in several studies [6, 7]. MPT is usually performed through a collection of blood samples either in the non-pregnant, dry, pregnant, or lactating stages. The following specific parameters are tested such as serum proteins, calcium, phosphorus, magnesium, blood urea nitrogen, liver enzymes, lipid profiles, β-hydroxybutyrate, glucose, sodium, potassium, and chloride [8-10].

By regular application of the MPT, huge economic costs can be saved as several diseases and disorders can be predicted and therefore early treated. Examples of these diseases that may be early diagnosed by the MPT are mastitis, ketosis, lameness, rumen acidosis, abomasal displacement, sub-acute rumen acidosis (SARA), metritis, retained fetal membranes, milk fever, hypophosphatemia, hypocalcemia and fatty infiltration of the liver [4, 11,

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(Received 30 November 2024, accepted 18 January 2025)
DOI: 10.21608/EJVS.2025.340543.2529

12]. If the MPT is not implemented in a commercial farm, the farm owners may suffer financial crises in the form of paying lots of money to veterinarians, medicines and supplies as well as a drop in milk yield, high culling rates, decreased reproductive efficiency and decreased cows' welfare [13, 14].

Mostly, MPT is performed in dairy cows during the very critical peri-parturient stage that extends for six weeks; precisely twenty-one days before until twenty-one days after birth) [15-23]. However, in the present investigation, we aimed to extend metabolic profiling in dairy cattle to 35 weeks; extending from ten weeks before expected until 25 weeks after birth. The objective was to monitor the metabolic status of the dairy cows during a long period extending almost 250 days of different reproductive phases.

Material and Methods

Animals and clinical examinations

Ten multiparous pregnant (2.8±0.65 years old) Holstein dairy cows from our university experimental station were enrolled in this study. At the beginning of the experiment, their body weight (BW) and body condition score (BCS) were 674±47.5 kg and 3.45±0.11 Units, respectively. BCS was estimated according to Edmonson et al., [24] and Ferguson et al., [25] based on a scale ranging from 1-5 units (1, thin; 5, obese). Cows' parity was from 2-6 (3.1±1.4). None of the selected cows suffered from any disorders and all had a good appetite. In addition, a thorough clinical examination including measuring vital signs by counting respiratory and pulse rates, measuring rectal temperature, visualizing mucous membranes, and palpating superficial lymph nodes as well as auscultation of the heart, lungs, and digestive system revealed nothing abnormal. Cows were managed in line with Qassim University Specifications of Laboratory Animals, which is parallel to the directions of the Use and Care of the National Institutes of Animal Health (USA, 86-23, modified 1996).

Design of blood sampling and determination of serum metabolites

To store serum, from each cow, 12 blood samples were collected in plain tubes just before the morning diet as follows. Before the expected parturition, 3 jugular vein puncture was carried out at -10wk, -7wk, and -3wk. Within 12 hours of parturition, a 4th blood sample was collected and named as 0 sample. After parturition, 8 blood samples were collected at weeks 1, 2, 3, 4, 5, 10, 15 and 25. At the end of the experiment, sera samples were analyzed for the determination of the serum activity of aspartate aminotransferase (AST), γ-glutamyl transferase (GGT), total bilirubin (TBIL), total cholesterol (T-Cho), non-esterified fatty acids (NEFA), triglycerides (TG) and ketone bodies (KB) (Abaxis, VS2, VetScan, California, USA).

Statistical analysis

Results were expressed as means ± standard deviations and were compared among different weeks using repeated measures of analysis of variance [26]. A value of P equal to or less than 0.05 was considered significant.

Results

In none of the experimental cows was observed any clinical illness throughout the experimental period which extended for 12 weeks before and after birth. Table 1 summarizes the results of BW, BCS, AST, GGT, and TBIL in healthy dairy cows starting from 10 weeks from the expected parturition until 25 weeks after birth. Compared to values at 10 weeks before parturition (674±47.5 kg), the BW increased significantly at value at 3 weeks before parturition (734±40 kg) ($P=0.05$). However, BW decreased gradually until week 5 after parturition (427±29 kg) with a significant difference from levels at -10wk ($P=0.05$) and at -3wk ($P=0.001$) (Fig. 1A). Significant decreases were detected when the BCS values after parturition, extending from 1wk until 25wk postpartum, were compared with that pre-partum extending from -10wk until -3wk ($P<0.05$) (Fig. 1B). The AST activity increased significantly at parturition (91 U/L) compared to -10wk activity (63 U/L) ($P=0.02$), and the activities remained high through weeks 1,2,3,4 and 10 after parturition compared to tested weeks before parturition ($P<0.05$) (Fig. 2A). Contrary, the GGT activity did not differ significantly between results obtained after versus before parturition ($P>0.05$) (Fig. 2B). The TBIL concentration increased gradually starting from -3wk before expected parturition until 1wk after parturition ($P<0.05$), then the concentration decreased gradually until 15wk after parturition with a statistical difference compared to values at parturition ($P=0.01$) (Fig. 2C).

Table 2 shows the results of lipid profiles (T-Cho, NEFA, TG) and TK in healthy dairy cows starting from 10 weeks from the expected parturition until 25 weeks after birth. Starting from -10wk before parturition, the concentration of T-Cho decreased significantly until birth then started to increase gradually until 10wk after parturition ($P=0.01$) (Fig. 3A). The concentration of NEFA increased significantly at birth and 1wk after parturition compared to tested weeks before birth ($P=0.001$). The levels were also high at 4wk, 5wk, and 10wk after birth compared to tested weeks before parturition ($P=0.01$) (Fig. 3B). The TG concentration increased significantly at -7wk and -3wk compared to -10wk before parturition. At and after parturition, TG concentrations did not differ significantly from those before parturition (Fig. 3C). The concentration of total ketones increased significantly from parturition until 10 weeks after parturition ($P<0.05$) (Fig. 3D).

Discussion

For early diagnosis, MPT is predominantly carried out in dairy animals during the periparturient period when most production disorders are observed [3]. In this way, transition period diseases could be expected in dairy cows by applying MPT This, will subsequently decrease the incidence of metabolic diseases, improve productivity, lower the money loss, improve the cows' welfare, and of course, decrease the culling rates [4]. Almost MPT is used to assess the metabolic health status in dairy animals [27].

Several metabolic or production diseases are well known to affect dairy cattle, especially during the late pregnancy and early lactation weeks. Of these, the most critical diseases are ketosis, SARA, and hypocalcemia. Almost all cows during the first two to three weeks of lactation are at a high risk of ketosis, especially in those with a BCS of ≥3.75. BY measuring serum concentrations of KB and NEFA, ketosis may be predicted principally in the subclinical form [28]. SARA is best suspected when rumen pH decreases lower than 5.5-5.6. Additionally, the content of milk fat is generally used to predict SARA. The third metabolic disease, hypocalcemia is usually diagnosed if calcium concentration decreases in blood less than 5.5 mg/dL [28]. Other metabolic diseases periodically detected in dairy cows include rumen acidosis, mastitis, metritis, lameness, hypophosphatemia, retained placenta, abomasal displacement, milk fever, and fatty liver [4].

Monitoring the status of dairy cows through periodic use of MPT is therefore crucial to detect metabolic disorders during pregnancy, lactation, and even during the dry period [29, 30]. To predict discrimination among some metabolic diseases including fatty liver, hypocalcemia, and ketosis, researchers have pointed out the effectiveness of measuring some serum parameters including T-Cho, urea, albumin, total proteins, fibrinogen, TG, AST, and TG [31]. This is especially important as metabolic diseases affect deeply the financial sides of the stakeholders including the costs of early mortalities, reduction in milk yield, losses in reproduction, and veterinary costs [32, 33]. In addition, affection by metabolic diseases leads to early and high percent of culling rates [34]. Some researchers therefore developed predictive models to early detect and avoid such metabolic diseases through the application of preventive strategies [35].

In the current study, selected cows were clinically healthy and did not suffer from any apparent illness. In our cows as a result of approaching parturition, BW increased significantly then decreased after parturition and this decrease was also parallel to significant decreases in the cows' BCS. The increased AST activity and NEFA and BHBA concentrations at parturition were also reported in dairy cows around parturition [16-18, 36]. Female camels at parturition also observed Significantly elevated AST activity [22]. In this study, the concentration of T-Cho decreased significantly until birth and then increased gradually. A study conducted in goats also noted that the concentration of T-Cho decreased toward birth significantly and then increased post-partum [21]. The TG concentration did not differ significantly at birth versus before parturition; this agrees also with our previous report on goats [21]. It is also reported that several blood metabolites including AST, alkaline phosphatase, creatine kinase, NEFA, globulin, glycogen, BHBA, albumin, glucose, total protein, phosphorus, magnesium, calcium, progesterone, and estrogen vary during the periparturient period in the healthy farm animals [3].

Conclusion

In the present study, significant changes were observed in dairy cattle in several parameters starting from 10 weeks before until 25 weeks after parturition. These variables included BW, BCS, AST, TBIL, T-Cho, NEFA, and KB. These changes are considered physiological as all cows enrolled in this study were healthy and did not show any sign of illness throughout the whole experimental period. The negative energy balance during the last 10 weeks of pregnancy and the first 25 weeks of lactation may be the predisposing cause for all these changes. In conclusion, the metabolic profiling test is a prognostic indicator of the healthy condition of dairy cows during a long period that extends almost 250 days of different reproductive phases.

Acknowledgments

Not applicable.

Funding statement

This study didn't receive any funding support

Declaration of Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical of approval

This study follows the ethics guidelines of the Colleague of Veterinary Medicine, Qassim University, Saudi Arabia.

TABLE 1. Body weight (BW), body condition score (BCS) and liver function tests in dairy cattle from week 10 before until week 25 after parturition (n=10).

	Weeks relation to parturition												
	-10	**-7**	**-3**	**0**	**1**	**2**	**3**	**4**	**5**	**10**	**15**	**25**	***P***
BW (Kg)	674±48	670±33	734±40	715±67	713±52	668±33	668±42	642±19	427±29	ND	644±4	662±22	0.05
BCS (Unit)	3.45±0.11	3.45±0.11	3.6±0.14	3.5±0.31	3.25±0.30	3.1±0.33	2.9±0.49	2.94±0.38	2.85±0.45	ND	2.85±0.22	2.95±0.21	0.001
AST (U/L)	63±7.7	59±8.8	60±6.6	91±20.7	92±19.8	100±11.9	102±28	93±18.9	76±12.4	87±9.0	76±11.8	76±13.9	0.02
GGT (U/L)	31±16	27±10	21±9	21±4	22±6	26±8	29±10	32±9	33±11	31±9	34±13	29±8	0.3
TBIL (mg/dL)	0.26±0.06	0.42±0.18	0.34±0.06	0.66±0.28	0.56±0.27	0.4±0.29	0.34±0.15	0.33±0.05	0.3±0.07	0.3±0.1	0.2±0.02	0.2±0.02	0.01

AST, aspertate amotransferase; GGT, gamma glutamyl transferase; TBIL, total bilirubin

TABLE 2. Lipid profiles and total ketones in dairy cattle from week 10 before until week 25 after parturition (n=10)

	Weeks relation to parturition												
	-10	**-7**	**-3**	**0**	**1**	**2**	**3**	**4**	**5**	**10**	**15**	**25**	***P***
T-Cho (mg/dL)	201±63	134±42	110±29	63±16	85±49	102±21	121±43	153±64	193±55	276±73	254±60	264±53	0.01
NEFA (mEq/L)	0.18±0.03	0.15±0.02	0.18±0.04	0.65±0.2	0.41±0.2	0.3±0.2	0.45±0.1	0.39±0.2	0.27±0.08	0.35±0.09	0.17±0.03	0.16±0.02	0.01
TG (mg/dL)	10.6±2.9	16.8±3.1	19.2±4.2	11.2±4.4	9.2±2.1	9.8±2.4	9.0±1.9	9.5±1.9	10.21.3±	8.6±1.3	10.8±4.4	9.0±4.5	0.7
KB (µMol/L)	578±140	507±115	486±152	790±213	941±562	1029±560	955±509	1000±749	1348±127	797±211	544±170	601±218	0.02

T-Cho, total cholesterol; NEFA, non-esterified fatty acids; TG, triglycerides; KB, ketones bodies

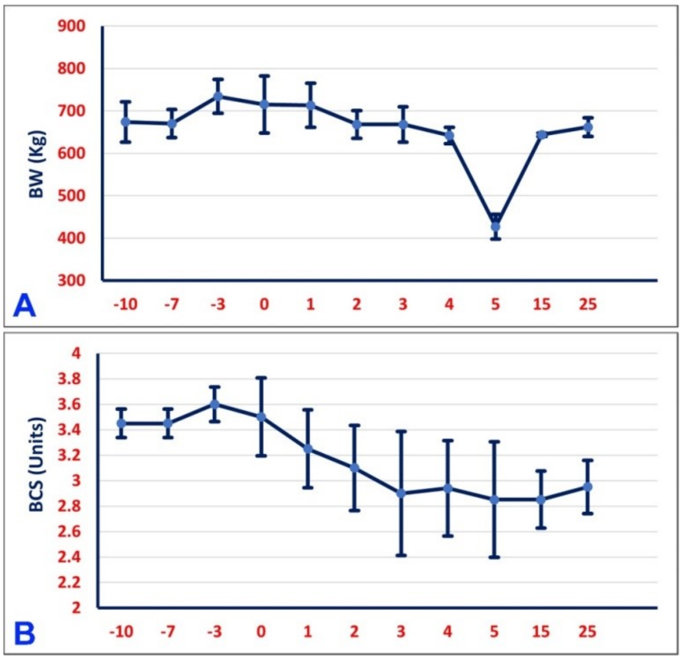

Fig. 1. Patterns of body weight (BW) (A) and body condition score (BCS) (B) in dairy cows starting from 10 weeks before expected parturition until 10 weeks after birth.

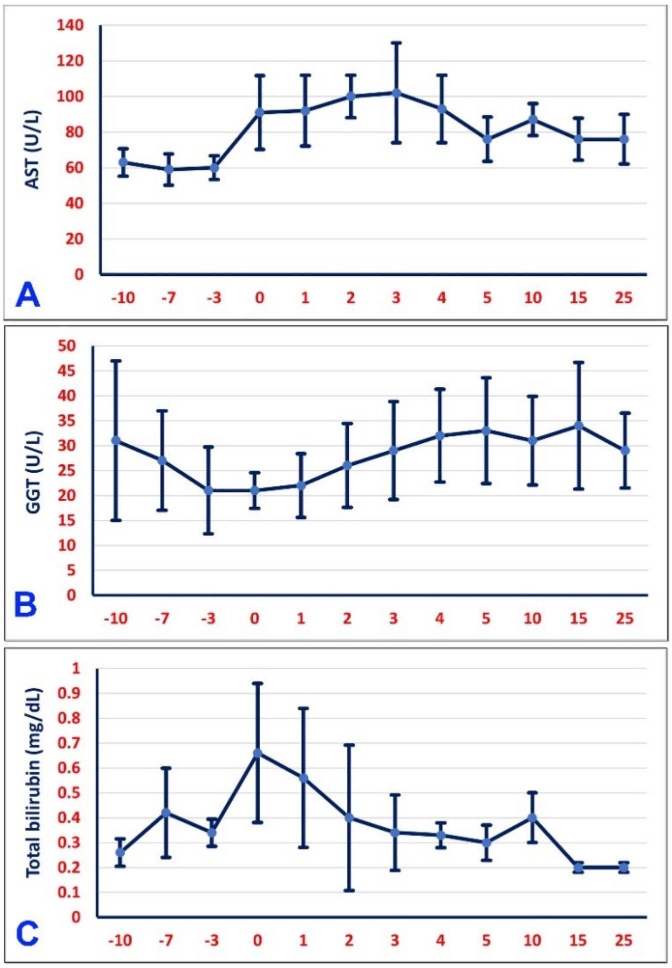

Fig. 2. Aspertate aminotransferase (AST) (A), gamma-glutamyl transferase (GGT) (B) and total bilirubin (C) in dairy cows starting from 10 weeks before expected parturition until 10 weeks after birth.

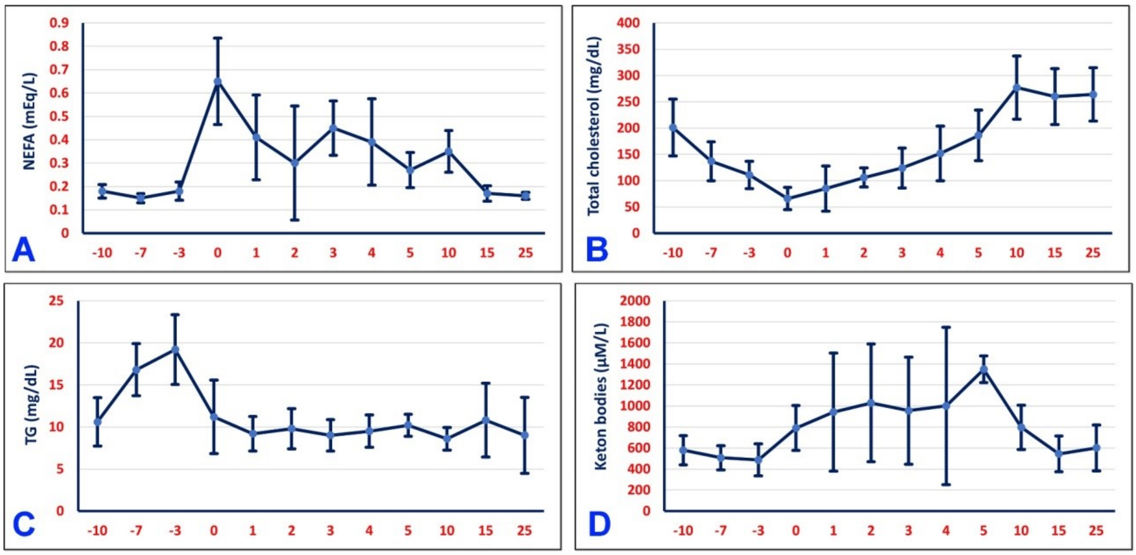

Fig. 3. Non-esterified fatty acids (NEFA) (A), total cholesterol (B), triglycerides (TG) (C) and keton bodies in dairy cows starting from 10 weeks before expected parturition until 10 weeks after birth.

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النمط الأيضي 10 أسابيع قبل الولادة وحتى 25 أسبوعًا بعد الولادة في الأبقار الحلوب

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[3] قسم الجراحة – مجموعة سلام البيطرية - القصيم - المملكة العربية السعودية.

الملخص

تم التخطيط للتجربة لمراقبة الحالة الأيضية لأبقار الحلوب من 10 أسابيع قبل الولادة وحتى 25 أسبوعًا بعد الولادة. ولهذا الغرض، تم استخدام 10 حالات لقاح متعددة الولادات تتمتع بصحة جيدة سريريًا. تم جمع اثنتي عشرة عينة دم ومن ثم الأمصال من كل بقرة على النحو التالي: قبل الولادة المتوقعة عند -10 أسبوع، -7 أسبوع، و -3 أسبوع، خلال 12 ساعة من الولادة، وبعد الولادة في الأسابيع 1، 2، 3، 4، 5، 10. و 15 و 25. وبالمقارنة مع القيم عند 10 أسابيع قبل الولادة، زاد وزن الجسم بشكل ملحوظ عند 3 أسابيع. ومع ذلك، انخفض وزن الجسم تدريجياً حتى الأسبوع الخامس بعد الولادة مع اختلاف كبير عن المستويات عند -10 أسبوع و -3 أسبوع. زاد نشاط AST بشكل ملحوظ عند الولادة مقارنة بنشاط -10 أسبوع؛ ظلت مرتفعة خلال الأسابيع 1،2،3،4 و10 بعد الولادة. لم يختلف نشاط GGT بشكل كبير بين النتائج التي تم الحصول عليها بعد الولادة وقبلها. ارتفع تركيز البيليروبين الكلي تدريجياً بدءاً من -3 أسبوع قبل الولادة المتوقعة وحتى أسبوع واحد بعد الولادة، ثم انخفض تدريجياً حتى 15 أسبوع بعد الولادة مع وجود فرق إحصائي مقارنة بالقيم عند الولادة. بدءاً من -10 أسابيع قبل الولادة، انخفض تركيز الكوليسترول الكلي بشكل ملحوظ حتى الولادة ثم ارتفع تدريجياً حتى 10 أسابيع بعد الولادة. زاد تركيز الأحماض الدهنية غير الأسترودية بشكل كبير عند الولادة وبعد أسبوع واحد من الولادة مقارنة بالأسابيع التي تم اختبارها قبل الولادة. وكانت المستويات مرتفعة أيضًا عند 4 أسابيع و5 أسابيع و10 أسابيع بعد الولادة مقارنة بالأسابيع التي تم اختبارها قبل الولادة. زاد تركيز الدهون الثلاثية بشكل ملحوظ عند -7 أسابيع و-3 أسابيع مقارنة بـ -10 أسابيع قبل الولادة. مما سبق يستنتج ان اختبار النمط الأيضي مؤشرا إنذاريا للحالة الصحية للأبقار الحلوب خلال فترة طويلة تمتد تقريبا 250 يوما من مراحل التكاثر المختلفة.

الكلمات الدالة: الأبقار، اختبار النمط الأيضي ، علم وظائف الأعضاء، الحمل، الولادة.