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Relationships between uterine health and metabolism in dairy cows with different dry period lengths

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ABSTRACT

The first objective of this study was to evaluate effects of dry period (**DP**) length and dietary energy source on ovarian activity, uterine health status, pregnancy rate, and days open in dairy cows in the second subsequent lactation after implementation of DP length and dietary treatments. The second objective was to determine relationships of uterine health status with ovarian activity, milk yield, energy balance (**EB**), and metabolic status in dairy cows. Holstein-Friesian dairy cows (n = 167) were assigned randomly to 1 of 3 DP lengths (0-, 30-, or 60-d) and 1 of 2 early lactation diets (glucogenic or lipogenic diet) for 2 subsequent lactations. Milk samples were collected three times a week. At least two succeeding milk samples with concentration of progesterone ≥2 ng/mL were used to indicate the occurrence of luteal activity. Vaginal discharge was scored in wk 2 and 3 after calving to evaluate uterine health status and cows were classified as having a healthy uterine environment [**HU**, vaginal discharge score (**VDS**) = 0 or 1 in both wk 2 and 3], a recovering uterine environment (**RU,** VDS = 2 or 3 in wk 2 and VDS = 0 or 1 in wk 3), or a non-recovering uterine environment (**NRU**, VDS = 2 or 3 in wk 3). Cows were monitored for milk yield, dry matter intake (**DMI**), and blood was sampled weekly to determine metabolic status from calving to wk 3 postcalving. Dry period length was not related with uterine health status in early lactation, pregnancy rate, or days open in dairy cows. Independent of DP length, feeding a glucogenic diet shortened the interval from calving to onset of luteal activity (25.3 vs. 31.0 d, $P = 0.04$), but decreased pregnancy rate compared with a more lipogenic diet (68.2 vs. 78.1 d, $P = 0.03$). In the first 3 wk after calving, cows with a NRU had lower milk yield (36.8 vs. 36.8 vs. 32.4 kg for cows with a HU, RU, or NRU, respectively; $P < 0.01$) and lower DMI than cows with a HU or RU. Cows with a RU had lower plasma glucose and insulin concentrations than cows with a NRU or HU. In conclusion, DP length did not influence fertility measures and uterine health status in the second subsequent lactation after implementation of DP length treatments. Independent of DP length, feeding a glucogenic diet leaded to earlier ovulation postcalving, but decreased pregnancy rate compared with a more lipogenic diet. In addition, a healthy uterine environment was related to greater milk yield and better metabolic status, independent of DP length.

1. Introduction

In modern high-producing dairy cows, low fertility is a substantial concern [1]. Recently, several studies reported that shortening the conventional dry period (**DP**) of 60 dto a short DP of 30 d or omitting the DP completely improved fertility in dairy cows by improving the resumption of ovarian cyclicity [2], decreasing the interval from calving to first ovulation [3], and decreasing days open [4] in subsequent lactation. The beneficial effects of shortening or omitting the DP on fertility were mainly related to an improved energy balance (**EB**) and improved metabolic status due to decreased milk yield in the subsequent lactation [2,4]. For application of this DP management strategy in practice, it is necessary to determine the long-term effects of shortening or omitting the DP on performance, health and fertility in dairy cows.

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Previously, we found that the milk yield losses were reduced, improvement of EB and metabolic status in early lactation was less pronounced in cows with a 0 or 30 d DP in the second subsequent lactation after implementation of the DP length treatments compared with the first subsequent lactation [5]. Because of the reduced improvement of EB, it can be hypothesized that the beneficial effects of shortening or omitting the DP on fertility is also less pronounced in the second subsequent lactation after implementation of the DP length treatments compared with the first subsequent lactation.

Besides the improved energy balance in early lactation, an improved resumption of ovarian cyclicity could also be related to an improved uterine health status in the postcalving period. Prolonged luteal phase has been related to uterine infection in dairy cows [6]. Vaginal discharge score can be considered as an indicator for uterine bacterial infection [7]. Vaginal discharge is related to the bacterial load in the uterine lumen [7] and is widely used to diagnose clinical metritis and endometritis in dairy cows [8,9]. Both clinical metritis [10] and endometritis [11] compromise reproductive performance as it is related with lower pregnancy rates, more services per pregnancy, and more days open [11]. Risk factors for metritis are calving problems, like dystocia, and retained placenta [12]. More recently, there are also indications that metabolic status during the dry period [13] and in early lactation [10] affect the risk for metritis, which might imply a relationship between uterine health status and energy balance of dairy cows in early lactation.

In the first subsequent lactation after implementation of the DP length treatments, feeding a glucogenic diet improved energy balance after a short DP [14] and decreased plasma beta-hydroxybutyrate (BHB) concentration [15], but had no influence on fertility [2] compared with a lipogenic diet. In the second subsequent lactation after implementation of the DP length treatments, feeding a glucogenic diet considerably improved metabolic status in early lactation of the second subsequent lactation compared with a lipogenic diet, as indicated by greater plasma glucose, IGF-1, and insulin concentrations, and lower plasma free fatty acids (FFA) and BHB concentrations. Increased plasma insulin and insulin like growth factor 1 (IGF-1) concentrations have been positively associated with the growth and maturation of follicles [16,17]. Thus, it may be expected that feeding a glucogenic diet improves fertility of cows in the second subsequent lactation compared with a lipogenic diet.

In this study, cows were followed for 2 subsequent lactations with same DP management strategy and dietary strategy in both lactations. Results of the first subsequent lactation on EB [14], metabolic hormones [15], and fertility [2] were reported earlier. In the first subsequent lactation after implementation of DP length treatment, reducing the DP decreased milk yield [14], but improved EB [14], metabolic status [15], and fertility [2] in early lactation compared with the conventional DP in dairy cows. The primary objective of this study was to evaluate effects of DP length and dietary energy source on ovarian activity, uterine health status, pregnancy rate, and days open in dairy cows in the second subsequent lactation after implementation of DP length and dietary treatments. The second objective was to determine relationships of uterine health status with ovarian activity, energy balance, milk yield, and metabolic status in dairy cows.

2. Material and methods

2.1. Animals and experimental design

The Institutional Animal Care and Use Committee of Wageningen University approved the experimental protocol. The registration number of the experimental protocol is 2010026. A total of 167 Holstein-Friesian dairy cows (60 primiparous and 107 multiparous) were selected from the Dairy Campus Research herd (WUR Livestock Research, Lelystad, the Netherlands). The experimental design, DP lengths, and dietary contrast have been reported previously [14]. Briefly, dairy cows were blocked by parity, expected calving date, milk yield in previous lactation, and body condition score (BCS). Within blocks, cows were assigned randomly to a 3×2 factorial design with 3 DP lengths (0-, 30-, or 60-d) and 2 early lactation diets (glucogenic or lipogenic). Cows with a 0-d DP were milked twice daily until calving. Before calving, dry cows were fed a dry cow diet, while lactating cows were fed a lactation diet supporting 25 kg of milk. From 10 d before the expected calving date, cows were fed 1 kg/d of a glucogenic or lipogenic concentrate. From calving until 100 days in milk (**DIM**), the concentrates supply increased stepwise by 0.5 kg/d until concentrates supply reached 8.5 kg/d. After 100 DIM, all cows were fed the same standard lactation concentrate. Details on diet composition were presented earlier [14]. The main ingredient for the glucogenic concentrate was corn and the main ingredients for the lipogenic concentrate were sugar beet pulp, palm kernel, and rumen protected palm oil. Forage was offered ad libitum throughout the study, comprising of grass silage, corn silage, wheat straw, and rapeseed meal or soybean meal (51:34:2:13, DM basis). Diets were formulated to be isocaloric (net energy basis; Dutch net energy evaluation (**VEM**) system [18] and equal in intestinal digestible protein and degraded protein balance (**DVE/OEB**) system [19]. Cows were housed in a free stall with a slatted floor and cubicles, and were milked twice daily (at 0500 and 1630 h).

Cows were planned to have the same DP length and dietary treatments over 2 subsequent lactations. Results of the first subsequent lactation on EB and milk yield [14], metabolites and metabolic hormones [15], and fertility [2] have been reported earlier. After the first subsequent lactation, 20 cows with a 0-d DP, 15 cows with a 30-d DP, and 6 cows with a 60-d DP were excluded from experiment because of health problems or not being pregnant. The second subsequent lactation started with 130 cows (39 cows with a 0-d DP, 41 cows with a 30-d DP, and 50 cows with a 60-d DP). Of the 39 cows which were in the 0-d DP group in the first lactation, 19 cows were attributed to a new group (0 → 67-d DP group, actual days dry: 67 ± 8 d). These 19 cows had a very low milk yield (<4 kg/d) at least 30 d before expected calving date and were allowed to go dry. These cows went dry without use of intramammary antibiotics. As a result, there were 4 DP length groups in total in the second subsequent lactation after implementation of DP length treatments: 20 cows with a 0-d DP, 41 cows with a 30-d DP, 50 cows with a 60-d DP, and 19 cows with a 0 → 67-d DP. The drying off protocol for cows with the 30-d and 60-d dry period consisted of a transition to the far-off ration at day 7 before drying-off, and milking once daily at day 4 before drying-off cows. Cows with a 30-d or 60-d dry period were treated with an intramammary antibiotic at drying off (Supermastidol, Virbac Animal Health, Barneveld, The Netherlands).

2.2. Reproductive management

The voluntary waiting period was 50 d. Estrus detection was based on Lely Qwes-HR Activity Tags (Lely, Maassluis, the Netherlands) mounted on the neck collar of dairy cows. Activity data were recorded in a 2 h interval and artificial insemination was performed every 12 h after detection of oestrus. Pregnancy was confirmed by ultrasonography around 60 d after AI. First-service conception rate was determined by the number of cows diagnosed pregnant after first AI divided by the number of cows that received a first service postcalving ($n = 118$). Pregnancy rate was determined by the number of pregnant cows after the last service