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Original article

The impact of cow nutrition in the dry period on colostrum quality and immune status of calves

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Abstract

The objective of the study was to evaluate the effect of energy contents in a dry period diets in “7+1” feeding strategy of dry cow including 7 weeks of the dry period (far-off) and 1 week of a close-up period, on colostrum quality and the immune status of calves. Forty Holstein multiparous cows were dried at 56d before the expected date of calving and were assigned to the higher energy diet group (HE; 0.69 UFL/kg DM, NDF 52% DM), or the lower energy diet group (LE; 0.61 UFL/1kg DM, NDF 56% DM). From -7d to the expected calving date up to 21 d of lactation, all cows were fed the same fresh, lactation diet. Samples of colostrum were collected within 2h after parturition and its density, dry matter content and concentrations of immunoglobulins, fat, protein, lactose, urea and somatic cell counts were measured. Calves were weighed 2 h after calving and on the 21d of life. On 3d and 21d of calves’ life blood samples were collected and the concentration of IgG, IgA, IgM, insulin-like growth factor 1 (IGF-1) as well as total protein and albumin concentrations were determined. Treatments had no significant effect on composition of colostrum and serum immunoglobulins and IGF-1 concentration. In both groups the weight of calves at birth was similar, still daily body weight gain during 21 day of rearing period in HE group was higher than in the LE group (P=0.05).

Keywords: dry period, cow, calves, colostrum, immunoglobulins, IGF-1

Introduction

Nutrition and management throughout the dry period are crucial factors for the metabolic status of the dam and the health of calves (Davis and Drackley 1998). Shortening or omitting the dry period and new nutrition strategies have recently been widely discussed (Winkelman et al. 2008, de Feu et al. 2009). The traditional management practice includes a 5 week far-off period and 3-4 weeks of the close-up period (Hayirli et al. 2002). It is also known that the duration of the two periods could be critical and researchers must answer many questions to push back the frontiers of cow biology in the transition period (Drackley 1999). In a study conducted by Dann et. al (2006) overfeeding during the far-off period had a greater negative impact on peripartum metabolism than did differences in close-up period nutrition. The new dry-cow strategy: high-fiber, low-energy diet for the whole dry period, has been used with considerable success on multiple farms in France, UK, Australia and in USA (Beever 2006). Recently, Silva-del-Rio et al. (2010) reported that a moderate-energy diet during the entire dry period, compared to the traditional treatment (the far-off and close-up periods), improved the metabolic status and performance of lactating cows. According to Quigley and Drewry (1998) a relationship between the diet of the prepartum cow and passive immunity of calves requires further investigation. During the last 3 weeks of gestation 60% of the total fetal weight is gained and colostrum is synthesized, thus nutrient demand is greater as compared to the far-off period. Cow immune system during transition period is severely suppressed and a restriction of the maternal diet may alter the transfer of passive immunity to calves (Hough et al. 1990, Goff 2006). Lake et. al. (2006) concluded that the relationship between prepartum nutritional status and the transfer of passive immunity should be further studied to elucidate conflicting results in published data.

We hypothesized that maternal energy nutrition in dry period of a dam affects immune response of newborn calves. The objective of the study was to evaluate the effect of different energy concentrations of the diet in the dry period from 56 d to 8 d before parturition in the 7+1 system of dry cow feeding on colostrum quality and calves immune response.

Materials and Methods

All the procedures were approved by the Local Ethics Committee No. 10 in Poznań, Poland (64/2007).

According to body condition score, parity and previous lactation performance forty Polish Holstein-Friesian multiparous cows were allocated to

one of the two dietary treatments in dry period from -56 to -8d before expected parturition. The higher energy diet (HE group) consisted of 34.3% DM wheat straw (approx. 4.0 kg DM/d) and was formulated to meet 0.69 UFL in 1 kg DM (NDF 52%DM). The lower energy diet (LE group) contained more straw (i.e. 51.5%DM) approx. 6.0 kg DM/d, which reduced energy density to 0.61 UFL/kg DM (NDF 56% DM). Both diets were isonitrogenous (CP 11.5% DM). Diets were based on wheat straw, maize and alfa-alfa silages, soybean meal and were fed as TMR at 9.00 and 14.30 throughout the entire experimental period. From -7 d relative to the expected calving date to 21 d of lactation all cows were fed the same fresh lactation diet (0.82 UFL/kg DM, 98g PDI/kg DM CP 16.5% DM, NDF 35% DM) to provide adequate energy for cows with body weight of 650 kg and 30 l daily milk production. The ingredients and nutrient compositions of the diets are shown in Table 1. Daily dry matter intake was measured individually during transition period (-7d to 21d) and in groups during the dry period (-56d to -8d).

Table 1. Ingredients and nutrient composition of experimental TMR diets.

| Item | Dry period ¹ | | Transition ² |
|--|-------------------------|------|-------------------------|
| | HE | LE | |
| Ingredients (% of DM) | | | |
| wheat straw | 34.3 | 51.5 | |
| soybean meal | 4.3 | 7.7 | 9.0 |
| alfalfa silage | 18.9 | 12.9 | 12.8 |
| maize silage | 41.2 | 26.6 | 20.0 |
| grass silage | | | 11.8 |
| maize grain silage | | | 9.7 |
| sugar beet pulp silage | | | 5.6 |
| brewer's grain silage | | | 7.1 |
| hay | | | 6.7 |
| barley grain | | | 5.8 |
| triticale grain | | | 5.8 |
| glycerol | | | 1.3 |
| minerals and vitamins | 1.3 | 1.3 | 4.9 |
| Nutrient concentration (in kg DM) | | | |
| UFL | 0.69 | 0.61 | 0.82 |
| PDIN (g) | 66 | 68 | 98 |
| PDIE (g) | 69 | 72 | 98 |
| CP (%) | 11.4 | 11.5 | 16.5 |
| NDF (%) | 52.3 | 56.2 | 35.3 |
| ADF (%) | 34.1 | 37.3 | 20.3 |
| Ca (g) | 7.1 | 7.0 | 8.7 |
| P (g) | 3.3 | 3.4 | 3.6 |

¹ from 56d to 8d before expected calving

² from 7d before expected calving to 21d of lactation

The HE group was composed of 13 heifer calves and 7 bull calves, whereas the LE group comprised of 7 heifers and 13 bulls. Calves were separated from their mothers 2 h after birth and were placed in individual

plastic boxes. For the first 3 days of life they were fed colostrum in the amount of 10% of body weight. Throughout the entire experimental period the animals received 5 l whole milk twice a day and they were fed *ad libitum* with calf starter (21% CP, 1.1 UFL/kg), composed of protein concentrate (75%) and whole maize grain (25%). Animals had constant access to fresh water. Samples of colostrum were collected from cows within 2 h after parturition and the following parameters were measured: density (DMA 35N Density Meter), immunoglobulins concentration by Elisa using kits by Bethyl Inc., dry matter, protein and lactose content (Infrared Milk Analyzer 150, Bentley Instruments Inc.), somatic cell count (Somacount 150, Bentley Instruments Inc.), urea concentration (ChemSpec 150, Bentley Instruments Inc.).

Calves were weighed 2 hours after calving and on 21d of life.

On 3d and 21d of life blood samples were collected from the jugular vein to test tubes with a coagulant. Then the samples were centrifuged, the separated serum was frozen at -20°C and stored until analysis. In blood serum of calves the concentration of immunoglobulins IgG, IgA, IgM was determined using an Elisa reader with kits by Bethyl Inc., while the concentration of insulin-like growth factor 1 (IGF-1) was determined by radioimmunoassay using kits by Diagnostic Systems Laboratories Inc., USA. Total protein and albumin concentrations were determined using Pentra 400 by Horiba ABX.

Results were analysed statistically by Student's t-test using the SAS computer software SAS 9.1 (2004) and the PROC T-TEST procedure. Significance was declared at $P \leq 0.05$.

Results

The average daily dry matter intake in the dry period was similar for the both treatments and amounted to 10.45 and 10.65 kg, respectively in the LE and HE group. During the transition period before calving with the average duration 7.7 days in LE and 6.5 days in HE, the individual dry matter intake in both groups increased to 11.34 and 11.52 kg, and differences between groups were not statistically significant.

Fat, protein, lactose, casein and urea contents in colostrum were not significantly affected by the treatment (Table 2), also mean colostrum densities did not differ between the treatments. The concentration of IgA in colostrum was significantly higher ($P < 0.01$) in LE compared to HE group of cows. However, total immunoglobulins, G and M classes of immunoglobulin contents in colostrum were not affected by the treatment. Also total immunoglobulin, IgA, IgM and al-

bumin contents in blood serum at 3d and 21d day of life did not differ significantly between groups (Table 3). Concentrations of all serum immunoglobulin isotypes decreased approximately by 20% from 3 d to 21 d of life (Table 3). Serum IGF-1 concentration on 3d and 21d of age were not significantly affected. Although numerical differences were quite large, with means of 130.6 ng/ml for HE when compared with 99.3 mg/ml for the LE group on the 3d of life, the high degree of variability in IGF-1 content made it impossible to detect any significant differences. Birth weights of calves from cows fed HE and LE diets in the dry period were 45.1 and 46.3 kg, respectively, and the differences were not significant (Table 4). The average daily body gain from birth to 21d of life was significantly higher ($P = 0.05$) in the HE group (296 g) compared with that of calves from the LE group (165 g).

Discussion

Dry cow nutrition may affect quality of colostrum (Dann et al. 2006, Winkelman et al. 2008). Colostrum produced by cows and the way of its application to calves during the first day of life are main factors determining the efficiency of colostrum immunoglobulin absorption, and therefore the level of calves' passive anti-infectious immunity (Godden et al. 2009).

In our study the immunoglobulin level in colostrum was low, as for total Ig it was slightly above 32 mg/ml and for IgG 26.3 and 28.2 mg/ml in the HE and LE groups, respectively. In previous studies the effect of energy and protein content in the diet of dry period did not significantly affect the immunological quality of their colostrum (Houhg et al. 1990). In previous studies Olson et al. (1981) and Halliday et al. (1978) found that a restriction of maternal diet did not affect the transfer of passive immunity to calves. Burton et al. (1984) and Hough et al. (1990) reported in studies on beef cattle that a low protein and energy precalving diet reduced absorption of immunoglobulins by calves. Decrease of immunoglobulin absorption in calves of nutrient-restricted cows may depend on timing of nutrient restriction within gestation cycle (Lake et al. 2006).

In our study in spite of low contents of immunoglobulins in colostrum than traditionally has been considered to be acceptable for ensuring the health of newly born calves, total and particular classes of immunoglobulins in calves' serum exceeded values commonly considered as minimum (IgG > 10mg/ml), confirming sufficient level of their passive immunity. Concentration of all classes of immunoglobulins on 3 and 21d of life was similar in both groups. In the current study the lack of difference in colostrum composition

Table 2. Colostrum chemical composition and immunoglobulin concentration.

| | Unit | Group | | | <i>P</i> -value |
|------------|-------------------|-------|-------|-------|-----------------|
| | | HE | LE | SD | |
| Dry matter | % | 22.5 | 24.7 | 4.13 | 0.13 |
| Density | g/cm ³ | 1.057 | 1.055 | 0.013 | 0.62 |
| Fat | % | 5.69 | 7.27 | 3.12 | 0.16 |
| Protein | % | 13.9 | 15.0 | 4.08 | 0.47 |
| Lactose | % | 2.55 | 2.14 | 0.871 | 0.19 |
| Urea | mg/ml | 212 | 213 | 81.6 | 0.98 |
| SCC | 1000/ml | 1304 | 2600 | 2958 | 0.22 |
| Ig total | mg/ml | 32.8 | 34.9 | 8.69 | 0.50 |
| IgG | mg/ml | 26.3 | 28.2 | 7.71 | 0.50 |
| IgM | mg/ml | 5.52 | 5.45 | 2.02 | 0.91 |
| IgA | mg/ml | 0.953 | 1.28 | 0.322 | < 0.01 |

Treatments:

HE-calves from cows fed in the dry period diet with higher energy content – 0.69 UFL/kg DM

LE-calves from cows fed in the dry period diet with lower energy content – 0.61 UFL/kg DM

Table 3. Blood serum concentration of immunoglobulins, albumins (mg/ml) and IGF – 1 (ng/ml).

| | Day of life | | | | | | | |
|----------|-------------|-------|-------|-----------------|-------|-------|-------|-----------------|
| | 3 | | | | 21 | | | |
| | HE | LE | SD | <i>P</i> -value | HE | LE | SD | <i>P</i> -value |
| Ig | 20.5 | 19.4 | 6.68 | 0.60 | 15.6 | 15.6 | 4.85 | 0.99 |
| IgG | 17.3 | 16.2 | 6.50 | 0.61 | 14.1 | 13.9 | 4.49 | 0.92 |
| IgM | 2.70 | 2.76 | 1.01 | 0.86 | 1.29 | 1.41 | 0.66 | 0.65 |
| IgA | 0.359 | 0.356 | 0.167 | 0.96 | 0.214 | 0.243 | 0.121 | 0.53 |
| Albumins | 29.1 | 28.1 | 1.87 | 0.12 | 31.1 | 30.8 | 2.03 | 0.75 |
| IGF – 1 | 130.6 | 99.3 | 76.2 | 0.24 | 163.3 | 130.6 | 24.6 | 0.54 |

Treatments:

HE-calves from cows fed in the dry period diet with higher energy content – 0.69 UFL/kg DM

LE-calves from cows fed in the dry period diet with lower energy content – 0.61 UFL/kg DM

Table 4. Weight at birth (kg) and average daily body gain (g) during the first 21 days of life.

| | Group | | | |
|-----------------|-------|------|-------|-----------------|
| | HE | LE | SD | <i>P</i> -value |
| Weight at birth | 45.1 | 46.3 | 6.10 | 0.57 |
| Daily body gain | 296 | 165 | 212.9 | 0.05 |

Treatments:

HE-calves from cows fed in the dry period diet with higher energy content – 0.69 UFL/kg DM

LE-calves from cows fed in the dry period diet with lower energy content – 0.61 UFL/kg DM

and in total serum IgG suggesting that the energy density during the dry period in the “7+1” strategy of dry cow feeding had small effect on colostrum Ig concentration and immune response of neonatal calves. It seems also that the new strategy of implemented during dry

period for minimizing the potential effects of overconditioning and for improving metabolic status of lactating cows did not negatively affected that transfer of immunoglobulins from maternal serum to colostrum and suggesting that manipulation of colostrum IgG con-

centration by varying dam energy nutrition is ineffective.

Serum IGF-1 is useful indicator of nutritional status of farm animals, enhance immune function, long bone growth, maintains lymphocytic activity, increase nutrient availability (Dorshkind and Horseman 2001, Taylor et al. 2004). Although serum IGF-1 on the 3d and 21d of life concentration was not significantly affected by nutritional treatment, a higher level of IGF-1 of about 30% was observed in the group of calves which mothers were fed a higher energy diet in the dry period. Also higher IGF-1 level (approx. 25%) was also demonstrated on the 21d of life. Pagano et al. (2001) observed a lower IGF-1 level in serum of hypertrophic animals, which somehow may suggest negative relationship between body weight and IGF-1 in serum. Brickell et al. (2009) concluded that every 1ng/ml increase at 1 month age reduced mortality risk between 1 and 6 month. According to Sparks et al. (2003), the level of IGF-1 in calves' serum after the second day of life depends on its content in colostrum and a contribution in calves' serum after birth, with a negative relation demonstrated between these values. Studies of Hammon and Blum (1997) have shown a six-fold higher IGF-1 content in serum of calves that were given colostrum as compared to calves fed with milk replacer during the first week of life.

The average birth weights did not differ between treatments what suggests that in spite of increased requirements during the last 4 weeks of gestation, rations formulated in both groups provided adequate to support fetal growth. Similarly Winkelman et al. (2008) found no significant effect of a low energy diet in the dry period on calves' weight. Average daily weight gain from birth to 21d of life was significantly higher in the HE group when compared the LE group. It seems that higher energy density diets in dry period may indirectly affect growth of newborn without affecting immune status of calves. Specific definition of the mechanism with including metabolic function of IGF-1 requires further studies.

In conclusion, energy content of the diet during the dry period in feeding strategy of dry cow (7+1) did not significantly affect the immunological quality of colostrum, content of immunoglobulins and IGF-1 in blood serum of neonatal calves. We imply that cow energy nutrition during dry period with shortening transition period to one week does not affect colostrum quality and immune status of calves. However the research reported here indicated that higher energy content of dam diet during dry period result in increasing daily body gain of calves in the first 3 weeks of life. Further investigation is necessary to determine the effect of shortening or omitting of dry period on immune status of newborn calves.

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