J. Dairy Sci. 101:1–15
https://doi.org/10.3168/jds.2016-12504

Different durations of whole raw soybean supplementation during the prepartum period: Milk fatty acid profile and oocyte and embryo quality of early-lactating Holstein cows

R. Gardinal,* G. D. Calomeni,* F. Zanferari,* T. H. A. Vendramini,* C. S. Takiya,* T. A. Del Valle,* and F. P. Renno*†[1]
*Department of Animal Nutrition and Production, University of Sao Paulo, Pirassununga, Brazil, 13635-900
†Bursar 1-C of the National Council of Scientific and Technologic Development, Brasilia, Brazil, 716055-001

ABSTRACT

The objective of this study was to evaluate different durations of whole raw soybeans (WS) supplementation during the prepartum period on nutrient digestibility, milk yield and composition, energy balance, blood metabolites, and oocyte and embryo quality of transition cows. Thirty-one Holstein cows were used in a completely randomized design and assigned to 4 experimental groups (G): G90, G60, G30, and G0 (control), supplemented with a diet containing 12% of WS from 90, 60, 30, and 0 d relative to the calving date, respectively. Cows were dried off 60 d before the expected calving date. After parturition, all cows were fed a diet containing 12% of WS until 84 DIM. Blood samples were collected on d −49, −35, −21, −14, −7, 0, 7, 14, 21, 35, and 70 relative to partum. Ovum pick-ups were performed on d 21 ± 3, 42 ± 7, 63 ± 7, and 84 ± 7 of lactation. Different durations of WS supplementation did not affect DMI and apparent total-tract digestibility in either the pre- or postpartum periods. Duration of WS supplementation had no effect on milk yield and composition nor energy balance of cows. However, the duration of WS supplementation had several effects on milk fatty acid (FA) profile of cows, including a linear decrease in concentrations of *cis*-9 C18:1, unsaturated C18, total monounsaturated, and unsaturated FA. Further, the milk contents of *cis*-9,*cis*-12 C18:2 FA, *cis*-9,*trans*-11 C18:2 FA, and total polyunsaturated FA were increased when WS were fed to cows from 30 d but not from 60 or 90 d of the expected calving date. The length of WS supplementation in the prepartum period linearly increased blood cholesterol concentration of cows during the prepartum period, but it had no effect on blood glucose and nonesterified FA concentrations in the pre- and postpartum periods. Duration of WS supplementation during the prepartum period increased the average number of grade 2 oocytes, notably in G60, but it had no effect on embryo production and cleavage proportion of early-lactation cows. The duration of WS supplementation in the prepartum period had no effect on milk yield and energy balance of the subsequent lactation, but it altered milk FA profile in early lactation by decreasing unsaturated FA content, notably when starting to supplement WS at 90 and 60 d from the expected calving date. Our results also showed that the duration of WS supplementation during the prepartum period does not improve oocyte quality in the subsequent lactation of cows.

Key words: essential fatty acid, in vitro embryo production, linoleic acid, oilseed

INTRODUCTION

During the transition from 3 wk before parturition to 3 wk of lactation, several metabolic and hormonal changes occur that increase nutrient requirements to support milk production of fresh cows. However, DMI capacity lags behind energy requirements during early lactation, and so, the cow enters a state of negative energy balance (**NEB**). Negative energy balance is characterized by the mobilization of body reserves coupled with an increase of nonesterified fatty acids (**NEFA**) in an animal, which impair its reproductive function (Santos et al., 2008).

Supplying fatty acid (**FA**) sources to cows is a strategy to increase dietary energy density while minimizing NEB through the transition and early lactation. In addition, studies have demonstrated that UFA supplementation, particularly of n-3 and n-6 series, may influence the plasma FA amounts and profile, altering their availability in body tissues and benefiting animals' metabolism and health (Contreras and Sordillo, 2011). Whole raw soybean (**WS**) is rich in n-6 FA (mainly linoleic acid) and has a protein complex that surrounds

Received December 21, 2016.
Accepted July 15, 2017.
[1]Corresponding author: francisco.renno@usp.br

its lipid content, thus minimizing n-6 FA ruminal biohydrogenation (Lock and Bauman, 2004; Barletta et al., 2016) and increasing the transfer of PUFA into the milk of cows (Gandra et al., 2016).

Besides the effects on health, n-6 FA may directly or indirectly act on physiological processes in the reproductive system by promoting 2-series prostaglandin synthesis and serving as precursor for steroidal hormones (Zachut et al., 2008), altering the function and development of a cumulus–oocyte complex (Wonnacott et al., 2010), modifying gene expression in oocytes (Ponter et al., 2012), or improving embryonic development (Cerri et al., 2009).

According to Ireland (1987), folliculogenesis is a complex process that involves the formation and development of primordial follicles up to the stage of preovulatory follicles. The period required for a primordial follicle to reach a tertiary stage ranges from 80 to 100 d (preantral phase), and the period required for a tertiary follicle to achieve the preovulatory state (antral phase) is 42 d (Britt, 1994). Studies have positively correlated FA supplementation with antral follicle development (Ponter et al., 2012), but literature lacks data regarding the duration of FA supplementation in the prepartum period and its influence on follicle and embryo development in the subsequent lactation.

Our hypothesis was that the longer the duration of WS supplementation prepartum, the greater would be the PUFA content in milk fat, and the better would be the oocyte and embryo quality of early-lactating cows. Thus, the objective of this study was to examine different durations of WS supplementation during the prepartum period on milk yield and FA profile, and oocyte and embryo quality of early-lactating dairy cows. Dry matter intake and digestibility, as well as blood metabolites (cholesterol, triglycerides, glucose, urea, NEFA, and BHB) and energy balance (**EB**), of cows were also assessed.

MATERIALS AND METHODS

Data from this experiment are discussed in a companion paper. The present article describes the effects of different durations of WS supplementation in the prepartum period on productive and reproductive measures of early-lactating cows, and the other paper examined the influence of WS supplementation on measures of cellular immune function of cows (Gardinal et al., 2017).

Cows, Experimental Design, and Diets

Forty-four Holstein cows, in late lactation (20.3 ± 1.00 kg/d of milk yield, 332 ± 26 DIM) and 90 d from the expected day of parturition, were used in a completely randomized design study, balanced for milk production and BCS of cows. Cows were dried off 60 d before the expected calving date.

At the beginning of the study, 11 cows were assigned to each treatment; however, because of the occurrence of metabolic or infectious disorders not related to experimental treatments (3 abortions, 3 displaced abomasum, 3 foot disorders, and 4 dystocia), 13 cows were removed from the study, and only data of healthy cows were evaluated. Cows were distributed to 1 of 4 groups (G): **G90** (n = 8), **G60** (n = 10), **G30** (n = 6), and **G0** (control, n = 7), supplemented a diet rich in n-6 FA (12% WS on a DM basis) from 90, 60, 30, and 0 d relative to the expected calving date, respectively. After parturition, cows were fed a diet containing 12% of WS on a DM basis until 90 DIM. Diets (Table 1) were formulated according to NRC (2001) recommendations based on the milk production of the previous lactation and supplied twice daily (0800 and 1300 h) as a TMR. Diets presented similar NDF, ADF, and CP in each production stage (Table 1). Dietary ether extract (**EE**) and NE_L increased, whereas dietary NFC content decreased, with WS inclusion. As expected, the amounts and proportion of FA in diets fluctuated according to WS addition in the prepartum period. The calculated values of linoleic acid (% diet DM) in late-lactation diets were 2.4 for G90 and 0.9 for the other treatments. Linoleic acid dietary content (% DM) in far-off diets was 2.3 for G90 and G60, and linoleic acid was presented at 0.8% of diet DM for G90 and G0. In close-up diets, G90, G60, and G30 received a diet containing 2.4% of diet DM of linoleic acid, and G0 received a diet containing 0.8% of diet DM of linoleic acid. Diets for early-lactating cows had 2.4% of diet DM of linoleic acid.

At the start of the study, G0 was composed of cows with 2.4 ± 1.0 parturitions, 718 ± 30.6 kg of BW, 3.6 ± 0.20 BCS, and milk production of the last lactation of 26.3 ± 1.3 kg/d; G30 was composed of cows with 2.7 ± 1.0 parturitions, 678 ± 28.3 kg of BW, 3.5 ± 0.15 BCS, and milk production of the last lactation of 25.9 ± 1.2 kg/d; G60 was composed of cows with 2.2 ± 0.5 parturitions, 671 ± 26.1 kg of BW, 3.6 ± 0.15 BCS, milk production of the last lactation of 26.1 ± 1.5 kg/d; and G90 was composed of cows with 2.5 ± 0.5 parturitions, 652 ± 24.9 kg of BW, 3.5 ± 0.15 BCS, and milk production of the last lactation of 26.0 ± 1.3 kg/d (mean ± SD).

Throughout the study, cows were housed in individual pens (17.5 m^2 of area) containing forced ventilation, sand bedding, individual feed bunks, and free access to water. Amounts of feed offered and orts from each cow were weighed daily and restricted to 5 to 10% of feed