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# Effects of feeding cows in early lactation with soy hulls as partial forage replacement on heat production, retained energy and performance

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ABSTRACT

This study measured the effects of replacing corn silage and vetch hay by soy hulls in total mixed rations (TMRs) fed to 25 pairs of cows through 90 d in milk, on dry matter (DM) intake, *in vivo* digestibility, milk yield and composition, onset of normal estrous activity, body condition score (BCS), health and the energy balance of lactating cows. The partitioning of metabolizable energy (ME) intake between heat production (HP) and retained energy (RE) in milk and body change of each cow was measured. The two TMRs differed in the content of forage and forage aNDFom [235 g/kg *versus* 350 g/kg; and 128 g/kg *versus* 187 g/kg DM, in the experimental (EXP) and control (CON) diets, respectively]. This was reflected by an increase in voluntary DM intake by 7.2% ($P$=0.02) in the EXP group as compared with the CON. *In vivo* DM and aNDFom digestibility were 4.9% ($P$=0.03) and 22.7% higher ($P$=0.01), respectively, in the EXP group than in the CON. The higher DM intake and digestibility of the EXP TMR were reflected by a concomitant increase of 7.4% in milk yield and 10.8% in RE ($P$=0.01) of the EXP cows as compared with the CON. The two dietary groups expressed similar somatic cell counts, and metabolic disorders (*i.e.*, ketosis and/or lameness), as well as pedometer activity (steps/h) suggesting similar udder health, behavior and animal welfare. A trend to an earlier return to normal ovarian activity occurred in the EXP cows as reflected by fewer days to 1st ovulation and advanced outset of estrous cycle. Despite the higher RE of the EXP cows, the HP of both groups was maintained at an upper level of 141–136 MJ/cow/d during the 90 d of the experiment.



## 1. Introduction

According to NRC (2001), early lactation fresh cows are unable to supply their energy and protein requirements for milk production, and are compelled to mobilize energy sources from body reserves. Since maximum DM intake lags behind peak milk production, it usually results in a negative energy balance, large body weight and body condition score (BCS) losses

*Abbreviations:* ADFom, acid detergent fiber; BCS, body condition score; CON, control treatment; DIM, days in milk; DM, dry matter; EXP, experimental treatment; HP, heat production; HR, heart rate; ME, metabolizable energy; aNDFom, neutral detergent fiber; $NE_L$, energy in milk, maintenance and BCS change; OM, organic matter; RE, retained energy in milk and body change; SCC, somatic cell count; TMR, total mixed ration.

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and reduced milk production. In addition, there is often a radical shift from a high forage ration fed during the dry period to a low forage total mixed ration (TMR) fed immediately after calving, and this shift might cause additional stress to fresh cows.

The energy status of the fresh cow is an important factor that might influence the susceptibility of cows to metabolic diseases (Dann et al., 2005), affects normal ovarian activity and the onset of the estrous cycle. A negative energy balance might also elongate the period from calving to 1st ovulation, the number of silent cycles before 1st insemination, and decrease conception rate (Butler and Smith, 1989; Staples et al., 1989).

Despite the large energy requirements in the early stage of lactation, it is not recommended to increase the energy content of the TMR by the addition of starchy grains (NRC, 2001), because of possible inhibitory effects on cellulolytic microorganisms in the rumen, ruminal fiber digestibility and its utilization for milk and milk fat production (Miron et al., 2003). In addition, such grain supplementation might increase the risk of subacute rumen acidosis, lameness, and digestive disorders (NRC, 2001; Zebeli et al., 2007).

Recently, we suggested increasing the voluntary DM intake of mid-lactation cows by replacing part of the diet forage with byproducts high in readily digestible NDF, such as soy hulls. We demonstrated that feeding dairy cows during mid-lactation with soy hulls as partial forage replacement increased DM intake by 6.9% and milk yield by 5.5% (Adin et al., 2008; Miron et al., 2008, 2003). We also observed that cows fed the soy hulls TMR elevated retained energy (RE) in milk and body tissue, compared with the control group, but that treatment had no effect on measured heat production (HP) that was constant (130.4 MJ/cow/d *versus* 130.8 MJ/cow/d) in the two groups. Unfortunately, there is lack of information in the literature about energy distribution in early lactating cows that are limited in their intake capacity.

The research group of Brosh (2007) and Aharoni et al. (2005) has developed a new method that can directly measure the HP and RE in milking cows under commercial dairy conditions. This new method provides a powerful tool to understand effects of changing the forage content and digestibility of the TMR, on the partitioning of ME intake between HP and RE in milk and body change of fresh cows. These energetic data, together with DM intake measurement, can also be used to re-evaluate the methodologies used (NRC, 1989, 2001) to predict the net energy lactation ($NE_L$) content of TMR based solely on its individual ingredients.

The objectives of this study were: to measure effects of including soy hulls as partial replacer of corn silage and vetch hay in TMR fed to fresh cows until 90 DIM, on voluntary DM intake, *in vivo* digestibility, milk yield and composition, HP, RE in milk and BCS change, outset of estrous cycle and health of the cows. In addition, we compare actual $NE_L$ measured in this study with predicted $NE_L$ contents of NRC (1989, 2001).

## 2. Materials and methods

### 2.1. Cows, diets, and sampling procedures

Fifty Israeli Holstein cows were housed at the Agricultural Research Organization (ARO) dairy farm, in one shaded corral with free access to water, during the winter season. Cows were divided 3 weeks before predicted calving date into pairs to create two feeding groups, being experiment (EXP) and control (CON), of 25 cows each, similar in lactation number (3.38 and 3.30, respectively) and milk production at the previous lactation (11,999 and 11,923, respectively). The CON group was fed after calving a TMR containing 187 g/kg DM forage aNDFom, whereas the EXP group was fed a TMR that contained 128 g/kg DM forage aNDFom, in which one-third (DM) of dietary corn silage and vetch hay was replaced with soy hulls (Table 1).

The two TMRs were fed once daily at 10:00 for *ad libitum* intake, allowing for 0.05–0.10 orts and the cows were milked 3 times daily at 06:00, 14:00 and 22:00 h. Cows were fed individually via a computerized monitoring system designed to electronically identify individual cows and to control and record automatically daily feed intake of each cow (Miron et al., 2003). Voluntary daily DM intake of individual cows from calving to 90 d in milk (DIM) was determined based on DM content in TMR sampled daily and in individual cow feed refusals.

Milk yield (kg) and average pedometer activity (steps/h) of each cow were recorded daily by automatic meters (Afimilk SAE, Afikim, Israel). Milk samples were collected during three sequential milkings on a weekly basis throughout the study. Each set of milk samples for each cow was stored at 4 °C in the presence of a 2-bromo-2-nitropropane-1,3-diol, until analyzed for fat, true protein, lactose, urea and somatic cell count (SCC) by infrared analysis (Israeli Cattle Breeders Association Lab., Caesaria, Israel), using a Milkoscan 4000 (Foss Electric, Hillerod, Denmark). One veterinarian measured body condition scores (BCS) on a weekly basis on a scale of 1–5 according to NRC (2001).

The animal performance study was carried out according to guidelines of the ARO Animal Care Committee and under their supervision.

### 2.2. Chemical analyses

Feed and feed refusal samples were grounded to pass a 1 mm screen and analyzed according to the methods of AOAC (1990) for DM (925.40), total N (984.13), ether extract (920.39) and ash (923.03). Crude protein was calculated as NX6.25. Neutral detergent fiber (aNDFom) was determined according to Van Soest et al. (1991) using a heat stable amylase without sodium sulphite. Acid detergent fiber (ADFom), hemicelluloses, cellulose and lignin(sa) were determined using the sequential method of Van Soest et al. (1991). The Ankom apparatus ($Ankom_{220}$, Macedon, NY, USA) was used for