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# Impact of *Saccharomyces cerevisiae* fermentation product and subacute ruminal acidosis on production, inflammation, and fermentation in the rumen and hindgut of dairy cows

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ABSTRACT

The effects of a *Saccharomyces cerevisiae* fermentation product (SCFP) on microbial fermentation in the digestive tract, milk production, and inflammation response were determined in Holstein dairy cows under normal and subacute ruminal acidosis (SARA) conditions. Eight lactating dairy cows with ruminal and cecal cannulas were used in a cross-over design with 5 wk experimental periods. During the first experimental period, cows were randomly assigned to treatment, i.e. SCFP (Original XPC, Diamond V, Cedar Rapids, IA) or control. During the second experimental period, treatments were reversed. Experimental periods were separated by a two-week wash out period. During each period, the 4 cows on the SCFP treatment were supplemented with 14 g/d of SCFP in 126 g of ground corn, whereas the other four cows received 140 g ground corn only. During the first 4 wk of each experimental period, all cows received a basal diet. During week 5 of both experimental periods, a SARA challenge was conducted in all cows by replacing 208 g/kg of the basal diet with pellets of ground wheat and barley (50:50 on a weight basis). This SARA challenge increased the duration of rumen pH below 5.6 from 11.1 to 311.1 min/d, indicating successful induction of SARA. Inducing SARA reduced milk fat from 3.24 to 2.82%, and lowered the acetate to propionate ratio from 3.07 to 1.74 in rumen fluid, from 5.13 to 4.57 in cecal digesta, and from 4.81 to 4.34 in feces. Induction of SARA increased milk protein content from 3.23 to 3.32%, without a concomitant effect on milk protein yield. Inducing SARA also increased endotoxic lipopolysaccharide (LPS) in rumen fluid, cecal digesta and feces from 15,389 to 123,296 endotoxin units (EU)/mL, from 31,982 to 77,380 EU/mL, and from 29,679 to 77, 371 EU/mL, respectively. Concentrations of LPS, serum amyloid A, haptoglobin, and LPS-binding protein increased by 215.0, 250.6, 181.6 and 47.5%, respectively, in peripheral blood when SARA was induced. The SCFP did not affect feed intake, yields of milk, milk fat, and milk protein but it reduced the variation in rumen pH during control feeding. During the SARA challenge, SCFP tended to reduce ruminal LPS at 6 h after feed delivery, increased milk fat percentage (2.71 *vs* 2.92%, control *vs* SCFP), and reduced the extent

*Abbreviations:* ADF, acid detergent fiber; DM, dry matter; DMI, dry matter intake; FCM, fat corrected milk; Hp, haptoglobin; IL-6, interleukin-6; LBP, LPS binding protein; LPS, lipopolysaccharide; NDF, neutral detergent fiber; SAA, serum amyloid A; SARA, subacute ruminal acidosis; SCFP, *Saccharomyces cervesiae* fermentation product; TNFα, tumor necrosis factor alpha; TLR-4, soluble Toll-like receptors-4; VFA, volatile fatty acids.

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of SARA-associated inflammation response as indicated by a reduction in the concentration of the pro-inflammatory cytokine tumor necrosis factor α (0.09 *vs* 0.03 ng/mL, control *vs* SCFP). This shows that SCFP can attenuate some of the impact of SARA on production and health of dairy cows.



## 1. Introduction

A recent meta-analysis showed that feeding a *Saccharomyces cerevisiae* fermentation product (SCFP) improved milk production in dairy cows (Poppy et al., 2012). This improvement may be due to the stabilizing effect of SCFP on rumen (Williams et al., 1991). It has been proposed that SCFP may stabilize rumen fermentation by enhancing the growth of fiber digesting and lactate utilizing bacteria due to the metabolites of yeast fermentation, such as vitamins, amino acids, and organic acids (Wiedmeier et al., 1987; Callaway and Martin, 1997). Hristov et al. (2010) also reported that SCFP increases microbial protein synthesis in the rumen.

Recent reviews (Plaizier et al., 2008; Kleen and Cannizzo, 2012; Plaizier et al., 2012) have shown that SARA is a common and costly disease in high yielding dairy cows. Several of the symptoms of SARA, including inflammation, are caused by disturbed microbial fermentation in the rumen as well as in the large intestine, which increases the lysis and lipopolysaccharide endotoxin (LPS) shedding by gram-negative bacteria, and translocations of endotoxin from the digestive tract into the interior circulation (Andersen et al., 1994; Emmanuel et al., 2007; Plaizier et al., 2008, 2012). Therefore, it is assumed that the stabilizing effects of SCFP are be more beneficial for cows with SARA than for cows with a healthy digestive tract.

In a study in which readily fermentable grain feeding caused milk fat depression, SCFP supplementation attenuated this depression (Longuski et al., 2009). However, the authors were not able to fully identify the mechanism though which this occurred. A negative relationship between rumen LPS and milk fat content are frequently reported (Zebeli and Ametaj, 2009; Khafipour et al., 2009). In addition, the acute phase response commonly observed during SARA will cause a repartitioning of nutrients away from growth and production toward the synthesis of acute phase proteins in the liver and the proliferation of cells of the immune system (Klasing, 1998). We speculate that the alleviation effect of SCFP on the incidence of milk fat depression observed by Longuski et al. (2009) may be partially explained by an accompanying decrease in LPS in the digestive tract and LPS and acute phase proteins in the blood circulation.

Intravenous administration of between 10 and 1000 ng/kg of bodyweight of *Escherichia coli* LPS results in a rapid onset of fever, a rapid reduction of the leukocyte count followed by an increase in this count, and a between $10^2$ and $10^3$ increase in the blood plasma concentration of the acute phase protein serum amyloid A (SAA) (Jacobsen et al., 2004). In order to simulate *E. coli*-induced mastitis, Vels et al. (2009) infused 200 μg of LPS intravenously in dairy cows. This infusion increased the blood plasma concentrations of the cytokine tumor necrosis factor alpha (TNF-α) from non-detectable to 1.9 ng/mL, that of the acute phase proteins serum amyloid A (SAA and haptoglobin (Hp) from 19.8 to 149.7 μg/mL and from 71.4 to 1013.8 μg/mL, respectively. These increases during grain-induced mastitis were of a much lower magnitude as those observed after intravenous administration of *E. coli* LPS. Hence, the effect of translocated LPS from the digestive tract on the acute phase response and other measures of inflammation may differ from those of intravenously administered LPS.

We hypothesize that the effects of SCFP on production, inflammation, and fermentation in the rumen and hindgut are greater in cows with SARA than in healthy cows. One objective of the study was, therefore, to compare the effects of SCFP (Original XPC®, Diamond V, Cedar Rapids, IA) on feed intake, milk production, inflammation, and fermentation in the rumen and hindgut between lactating dairy cows with grain-induced SARA and control cows without SARA. An additional objective was to determine the relationship between LPS and pro-inflammatory cytokines and acute phase proteins in blood plasma during grain-induced SARA.

## 2. Materials and methods

### 2.1. Animals, diets, and experimental procedure

Four primiparous and four multiparous clinically health cows, received ruminal and cecal cannula on 62 ± 19 d prior to calving, and were used in a crossover experiment. At the beginning of the experiment, cows were fully recovered from the surgery, and were between 65 ± 16 d (mean ± SD) in milk, had body weights of 605 ± 60 kg (mean ± SD), and body condition scores between 2.75 and 3.0 (1–5 scale). The use of cows in this experiment was pre-approved by the University of Manitoba Animal Research Ethics Board. The cows were housed in individual pens and were cared for in accordance with the Canadian Council on Animal Care guidelines (CCAC, 1993).

The cows were blocked based on their parity (primiparous *vs* multiparous) and within block randomly assigned to one of two dietary treatments: (1) a basal diet plus 14 g of *S. cerevisiae* fermentation product (SCFP, Original XPC, Diamond V) mixed with 126 g/d ground corn, or (2) a basal diet plus 140 g ground corn only (Control). The SCFP additive was supplemented as a top dress once daily immediately after feed delivery.