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Does yeast (*Saccharomyces cerevisiae*) supplementation in calf starter modify feed intake and liveweight gain of dairy bull calves?

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ABSTRACT. The objective of the experiment was to study the possible effects of supplemental yeast culture in calf starter on feed intake, liveweight gain and health of dairy bull calves. Two feeding treatments consisted of a calf starter containing 0% and 0.1% supplemental yeast culture (Actisaf, 1.0×10^{10} CFU $\cdot g^{-1}$ *Saccharomyces cerevisiae* Sc 47) as a percentage of dry matter starter. In each feeding treatment 20 dairy bull calves were included. The calves were housed in insulated barn in four pens (3.0 × 3.5 m; 5 calves in each), providing 2.1 m^2 per calf. At the beginning of the experiment, the average liveweight of the calves was 56 ± 3.0 kg and the overall age was 20 ± 2.5 days. During the pre-weaning period (from 20 to 75 day of life) the calves received milk replacer 7.0 l $\cdot d^{-1}$ and starter concentrate as well as grass silage *ad libitum*. During the post-weaning period (from 75 to 195 day of life) the calves received grass silage *ad libitum*, but the amount of concentrate was restricted to 3 kg (air dry) for a calf per day. No treatment differences were observed in dry matter or energy intakes, liveweight gain or feed conversion ratio during pre-weaning or post-weaning periods. The use of *Saccharomyces cerevisiae* did not affect the incidence of diarrhoea, cough or bloat. Thus, no evidence show that *Saccharomyces cerevisiae* inclusion could have enhanced calf performance under the studied conditions. In the present experiment, the calves were healthy; however different results might be observed in calves in altered physiological conditions.

Introduction

Good growth performance of calves is an important aspect of dairy herd management. Replacement heifers need an appropriate start to become productive dairy cows, and successful rearing of bull calves allows to fully exploit their growth potential in beef production. The process of transitioning dairy calves from their neonatal reliance on nutrients supplied from milk or milk replacer to nutrients supplied from solid feed is of substantial economic importance for the producer (Khan et al., 2008). In many intensive dairy and beef systems, dairy calves are typically fed commercial calf starters and grass silage as solid feed during the first months.

Incorporation of microbial additives such as a culture of *Saccharomyces cerevisiae* to the diet has become a common practice in ruminant nutrition (Chaucheyras-Durand et al., 2008; Magalhães et al., 2008; Desnoyers et al., 2009, Kim et al., 2011). Influences of yeast culture supplementation on numerous growth and production traits have been studied in most ruminant age classes (Chaucheyras-Durand et al., 2008; Magalhães et al., 2008; Marden et al.,

2008; Pinos-Rodríguez et al., 2008; Desnoyers et al., 2009; Lascano and Heinrichs, 2009). *In vitro* and *in vivo* studies have shown that yeasts and yeast cultures stimulate growth of rumen cellulolytic bacteria (Callaway and Martin, 1997), which are critical for carbohydrate digestion and rumen development in newborn calves. This progress in rumen microbial activities might partially explain the improvements observed in calf growth when yeast or yeast culture were incorporated into the diet in some studies (Lesmeister et al., 2004; Galvão et al., 2005). It is also suggested that yeast culture improves health of the young calves' digestive tract and reduces morbidity and mortality. Diarrhoea in calves can be caused by pathogenic bacteria that attach and may or may not invade the intestinal cells of the host (Magalhães et al., 2008). It is possible that feeding animals with diet enriched with yeast culture may decrease the risk of diarrhoea by reducing the attachment and invasion of intestinal cells by pathogens, because they may bind to oligosaccharides present in the yeast cell wall (White et al., 2002; Pérez-Sotelo et al., 2005), minimizing the growth of enteric pathogens (Jensen et al., 2008) or reducing inflammatory response in the gut because of the metabolites of yeast culture (Jensen et al., 2007).

However, results are inconsistent in the literature, partially because of confounding effects of ration composition, level of yeast culture inclusion and source of yeast culture product tested. In addition, only a few studies have utilized pre-ruminant dairy calves. Therefore, the present experiment was designed to study the effects of supplemental yeast (*Saccharomyces cerevisiae*) culture in calf starter on feed intake, liveweight gain, feed conversion ratio and health of dairy bull calves. It was hypothesized that *Saccharomyces cerevisiae* addition in a dairy calf starter would increase feed intake and improve calves' liveweight gain and feed efficiency.

Material and methods

Animals, management and experimental design

The present experiment included two batches of 20 Nordic Red dairy bull calves each. The first batch of the calves started in April and the second in November 2013 in the experimental barn of Natural Resources Institute in Finland (Luke; former MTT Agrifood Research Finland) in Ruukki (Finland; 64°44′N, 25°15′E). Animals were managed in accordance to the Finnish legislation regarding the use of animals in scientific experiments. All calves were purchased from local dairy farms.

The calves were housed in an insulated barn in four pens (3.0 × 3.5 m; 5 calves in each), providing 2.1 m^2 per calf. The floor of the pen was built in 1/3 of metal slats and in 2/3 of rubber mats. The ambient temperature of the insulated barn varied between 11 and 20 °C in the winter (October–April) and between 15 and 23 °C in the summer (May–September). At the beginning of the experiment the calves in both batches were randomly placed in pens (5 calves per pen) and then randomly allotted to two feeding treatments.

The two feeding treatments consisted of a calf starter containing 0% (control = C) and 0.1% (yeast = Y) supplemental live yeast culture (Actisaf, 1.0×10^{10} CFU·g^{-1} *Saccharomyces cerevisiae* Sc 47) as a percentage of the dry matter (DM) starter. Both feeding treatments included 20 bull calves (4 pens, 5 calves in each). At the beginning of the experiment, the average liveweight (LW) of the calves was 56 ± 3.0 kg (mean ± SD) and the overall age 20 ± 2.5 days. During the whole 175-day experimental period (from 20 to 195 day of life) the calves were given free access to water from an open water bowl (1 bowl per pen). The bowls were 80 mm deep, 220 mm in diameter and of two litres capacity.

Feeds and feeding

During the pre-weaning period (from 20 to 75 day of life) the calves received a milk replacer (MR) at a dilution of 11.9% DM. The MR included (g·kg^{-1} DM) skim milk powder 300, whey powder 283, vegetable oil 190, whey fractions 100, hydrolysed wheat protein 65, wheat starch 50 and vitamin-mineral premix 12. In both treatments the MR was served by a computer-controlled feeder (two pens per feeder; Stand Alone 2 Plus, Förster, Engen, Germany; programme: Kalbmanager 4.2) in the feeding temperature of 37 ºC. The calves were assigned to the feeding treatments on 20 day of life, and between 20 and 62 day the highest possible MR allowance of the calves was 7.0 l· d^{-1}. All calves were weaned gradually from day 62 to 75 with reduction of MR allowance (less MR portions per day). During the pre-weaning period, the calves had free access to commercial pelleted calf starter and grass silage.

During the post-weaning period (from 75 to 195 day of life) the calves were fed grass silage *ad libitum*, but the amount of concentrate was restricted to 3 kg (air dry) for a calf per day. The commercial starter concentrate used during both pre- and post-weaning periods was supplied by A-Rehu Ltd. (Seinäjoki, Finland). The concentrate in the treatment C comprised (g·kg^{-1} DM) barley 333, rapeseed meal 174, wheat 80, barley fibre 72, molassed sugar beet pulp 70, soyabean meal 50,

oats 50, molasses 50, rapeseed cake 42, distilled solubles 40, $CaCo_3$ 20, vegetable oil mix 8, and vitamin, mineral and trace element premix 11. In the treatment Y the concentrate was otherwise the same, but comprised barley (332) and supplemental yeast culture (1) (*Saccharomyces cerevisiae* Sc 47). The used dose of yeast culture was established according to Lascano and Heinrichs (2009). Kim et al. (2011) stated that yeast has been typically included in calf diets at levels between 0.001% and 1%, with some positive effects on DM intake, rumen pH and nutrient digestibility.

The silage and concentrates were offered separately from feeder box three times a day (at 8:00, 12:00 and 18:00) with proportional refusals at 5% in *ad libitum* feeding. The unconsumed feed was collected and measured daily at 7:00. Daily solid feed intake was weighed pen wise (i.e. average for five calves).

The grass silage used in the present experiment was harvested from first-year stands grown in Ruukki (Finland). The silage was prepared from primary growth of *Phleum pratense* stand and harvested at early stages of maturity. The silage was cut using a mower conditioner, wilted for 5 h, harvested using a precision-chop forage harvester, ensiled in a bunker silo and treated with a formic acid-based additive (AIV ÄSSÄ; Taminco Finland Ltd., Oulu, Finland; $g \cdot kg^{-1}$: formic acid 590, propionic acid 200, ammonium formate 40 and benzoic acid 25) applied at a rate of 5 l per tonne of fresh forage.

Feed sampling and chemical analysis

During the experiment, silage sub-samples were taken twice a week, pooled over periods of four weeks and stored at –20 ºC prior to analyses. Thawed samples were analysed for DM, ash, crude protein (CP), crude fat, starch, fermentation quality (pH, water-soluble carbohydrates, lactic and formic acids, volatile fatty acids, soluble and ammonia N content of total N) and digestible organic matter in DM (D-value). Concentrate and MR subsamples were collected weekly, pooled over periods of 12 weeks and analysed for DM, ash, CP, crude fat and starch.

Fresh silage samples were analysed for fermentation quality by electrometric titration as described by Moisio and Heikonen (1989). The DM concentration was determined by drying at 105 °C for 20 h and organic matter (OM) concentration by ashing at 600 °C for 2 h. Oven DM concentration of silages was corrected for the loss of volatiles according to Huida et al. (1986). After drying, samples were milled by using sample mill (Sakomylly KT-3100, Koneteollisuus Oy, Helsinki, Finland) into 1 mm sieve. The CP content of feeds was determined by using a Dumas-type N analyser (Leco FP-428; Leco Corporation, St. Joseph, MI, USA), crude fat – according to Pesonen et al. (2013) and starch as described by Huuskonen et al. (2014). The silage samples were analysed for D-value as described by Huuskonen (2013).

Calculations

Concentration of metabolizable energy (ME) of the silage was calculated from the concentration of digestible organic matter (DOM) using equation (MAFF, 1984):

$$ME\ (MJ \cdot kg^{-1}\ DM) = 16.0\ (MJ \cdot kg^{-1}\ DM) \times DOM\ (kg \cdot kg^{-1}\ DM).$$

The ME values of concentrates and milk replacers were calculated as described by Schiemann et al. (1972).

The calves were weighed on two consecutive days at the beginning of the experiment and then after every 14 days during the pre-weaning period and every 28 days during the post-weaning period. The liveweight gain (LWG) was calculated as the difference between initial and final LW divided by the number of growing days. Intakes of MR, concentrates and silage were recorded daily. Overall, total DM intake (MR, concentrate and silage) and feed efficiency (kg $DM \cdot kg^{-1}$ LWG and $MJ \cdot kg^{-1}$ LWG) were also calculated. Health parameters such as faecal consistency (normal or diarrhoea), bloat, movements, cough, inflammations, e.g., pneumonia, swollen joints and hair loss, were monitored daily. Incidences are reported as a percentage of feeding days during the pre-weaning period.

Statistical analysis

The results were calculated across the two batches and are shown as least squares means. The pen (a group of five calves) was used as an experimental unit and thus the mean values for each pen were calculated. There were 4 pens per treatment (20 calves for each treatment). The average group feed intake and growth data were subjected to analysis of variance using the SAS MIXED procedure (version 9.3, SAS Institute Inc. Cary, NC; Littell et al., 1996). The statistical model used:

$$y_{jkl} = \mu + \beta_k + \alpha_j + (\beta \times \alpha)_{jk} + e_{jkl}$$

where: μ – overall mean, e_{jkl} – random error term, y_{jkl} – mean of five animals penned together (4 pens per treatment; l = 1,……,4). α, β and $\beta \times \alpha$ – effects of treatment, batch and their interaction, respectively.

P-values less than 0.05 are reported as statistically significant.

Results

Chemical composition and feeding values of the experimental feeds are presented in Table 1. The commercial starter concentrate contained ME 12.4 MJ·kg^{-1} DM and CP 198 g·kg^{-1} DM on average. The grass silage used was of good nutritional quality as indicated by the ME value as well as the CP content. The fermentation quality of the grass silage was good, as indicated by low pH value (3.96) and low contents of ammonia N (39 g·kg^{-1} total N) and volatile fatty acids (11 g·kg^{-1} DM). The silage used was restrictively fermented with high residual water-soluble carbohydrates concentration (56 g·kg^{-1} DM) and low lactic acid concentration (lactic + formic acid, 41 g·kg^{-1} DM). The MR used in the present experiment had typical chemical composition and feed values (Table 1).

Table 1. Chemical composition and feeding values of experimental feeds

Indices	Grass silage	Milk replacer	Control starter	Yeast starter
Dry matter (DM), g · kg^{-1} feed	287	943	856	865
Organic matter, g · kg^{-1} DM	932	910	920	922
Crude protein, g · kg^{-1} DM	138	216	203	193
Crude fat, g · kg^{-1} DM	39	114	38	40
Starch, g · kg^{-1} DM	5	100	313	295
Metabolizable energy, MJ · kg^{-1} DM	10.6	17.4	12.4	12.4

control starter – a calf starter containing 0% supplemental yeast culture, yeast starter – a calf starter containing 0.1% supplemental yeast culture (Actisaf, *Saccharomyces cerevisiae* Sc 47) of starter DM. Fermentation quality of grass silage: pH 3.96; volatile fatty acids 11 g·kg^{-1} DM; lactic + formic acid 41 g·kg^{-1} DM; water-soluble carbohydrates 56 g · kg^{-1} DM; ammonia-N 39 g·kg^{-1} total N; soluble N 423 g·kg^{-1} total N

There were no treatment differences in the MR, concentrate, grass silage and total DM intake of the calves during pre-weaning or post-weaning periods as well as on average during the whole experiment (Table 2). Since there were observed no differences in the feed intake or diet chemical compositions and feeding values, the energy and nutrient intakes were also at the same level in both treatments.

The average LW of the calves was 101 and 247 kg at the end of pre-weaning period and at 195-day of life, respectively (Table 3). There were no treatment differences in the average LW and LWG of the calves. The use of *Saccharomyces cerevisiae*

Table 2. Daily feed and nutrient intakes of dairy calves fed diets consisting calf starter containing 0% (control) or 0.1% (yeast) supplemental live yeast culture (Actisaf, *Saccharomyces cerevisiae* Sc 47) as a percentage of starter dry matter (DM)

Indices	Diets		SEM	*P*
	control	yeast		
Number of calves	20	20		
Number of pens	4	4		
Pre-weaning (between 20 to 75 days of age)				
milk replacer, kg DM · d^{-1}	0.71	0.72	0.010	0.41
concentrate, kg DM · d^{-1}	0.69	0.67	0.065	0.76
grass silage, kg DM · d^{-1}	0.30	0.25	0.019	0.17
total DM intake, kg DM · d^{-1}	1.70	1.64	0.087	0.64
metabolizable energy, MJ · d^{-1}	24.1	23.5	1.08	0.71
crude protein, g · d^{-1}	334	318	16.5	0.52
crude fat, g · d^{-1}	121	120	3.8	0.99
Post-weaning (between 75 to 195 days of age)				
concentrate, kg DM · d^{-1}	2.48	2.46	0.030	0.71
grass silage, kg DM · d^{-1}	2.80	2.73	0.103	0.66
total DM intake, kg DM · d^{-1}	5.27	5.19	0.125	0.65
metabolizable energy, MJ · d^{-1}	60.4	59.4	1.36	0.65
crude protein, g·d^{-1}	890	852	18.7	0.23
crude fat, g · d^{-1}	204	206	4.8	0.83
Average during the experiment				
milk replacer, kg DM·g · d^{-1}	0.24	0.24	0.003	0.41
concentrate, kg DM·g · d^{-1}	1.88	1.86	0.041	0.73
grass silage, kg DM·g · d^{-1}	1.97	1.91	0.074	0.60
total DM intake, kg DM·g · d^{-1}	4.09	4.01	0.107	0.64
metabolizable energy, MJ·g · d^{-1}	48.3	47.5	1.20	0.65
crude protein, g · d^{-1}	705	674	17.0	0.27
crude fat, g · d^{-1}	177	178	0.004	0.87

SEM – standard error of means

Table 3. Liveweights, liveweight gains, feed conversion rates and disorders of dairy calves fed diets consisting calf starter containing 0% (control) or 0.1% (yeast) supplemental live yeast culture (Actisaf, *Saccharomyces cerevisiae* Sc 47) as a percentage of starter dry matter (DM)

Indices	Diets		SEM	*P*
	control	yeast		
Number of calves	20	20		
Number of pens	4	4		
Liveweight, kg				
initial, at age of 20 days	57	55	3.3	0.71
at the end of pre-weaning	103	98	5.4	0.51
final, at age of 195 days	249	244	8.5	0.71
Liveweight gain, g · d^{-1}				
pre-weaning (between 20 to 75 days of age)	824	760	52.2	0.43
post-weaning (between 75 to 195 days of age)	1298	1304	35.6	0.92
average	1141	1123	37.1	0.75
Feed conversion ratio, kg DM · kg^{-1} liveweight gain				
pre-weaning	2.17	2.21	0.039	0.51
post-weaning	4.08	4.02	0.121	0.75
average	3.60	3.60	0.091	0.99
Energy convertion ratio, MJ · kg^{-1} liveweight gain				
pre-weaning	30.7	31.6	0.78	0.49
post-weaning	46.7	46.0	1.34	0.75
average	42.6	42.6	1.04	0.98
Disorders during pre-weaning period, % of feeding days				
diarrhoea	1.65	2.10	0.512	0.86
cough	1.54	1.41	0.380	0.67
bloat	0.19	0.11	0.118	0.33

SEM – standard error of means

did not affect the feed or energy conversion rates of the calves. Furthermore, the use of *Saccharomyces cerevisiae* had no influence on the incidence of diarrhoea, cough or bloat (days, % of feeding days during the pre-weaning period).

Discussion

In comparison to the recent Finnish experimental data sets for dairy bull calves fed diets based on MR, grass silage and concentrates in similar housing environments (Huuskonen et al., 2005, 2011a,b; Huuskonen and Khalili, 2008; Huuskonen, 2011), the average DM intake of calves during the pre-weaning and post-weaning periods was approximately 20% higher in the present experiment (1.67 and 5.23 kg DM·d^{-1}, for pre- and post-weaning period, respectively) than in the above-mentioned feeding trials (1.36 and 4.27 kg DM·d^{-1}). The high feed intake measured in the present study probably implies a good palatability of the starter concentrate used and a good health of the calves in the present experiment. The average LWG of the calves during the pre- and post-weaning period and during the entire experiment were 792, 1301 and 1132 g·d^{-1}, respectively. This data is slightly higher when compared with the results by Huuskonen and Khalili (2008) and Huuskonen et al. (2005, 2011a,b) about dairy bull calves fed diets based on MR, grass silage and concentrates under similar management conditions (724, 1258 and 1080 g·d^{-1}, respectively).

Contrary to the present study, supplemental yeast products have been shown to improve performance of dairy ruminants in some earlier studies, and the yeast impact was evident regarding the increased feed intake and milk production (Abd El-Ghani, 2004; Jouany, 2006; Stella et al., 2007). It have been reported that growth, feed intake and feed conversion ratio were improved by yeasts supplementation also in beef cattle and young ruminant animals (Lesmeister et al., 2004; Galvão et al., 2005). In neonatal dairy calves, Lesmeister et al. (2004) reported that inclusion of yeast culture (*Saccharomyces cerevisiae*) increased the starter and total DM intake and average daily gain when compared with the control treatment. However, results in dairy calves are inconsistent throughout the literature. Kim et al. (2011) reported no difference in feed intake, liveweight or feed efficiency when neonatal calves received either control calf starter or starter supplemented with 0.2% of hydrolysed yeast. Moreover, Quigley et al. (1992) observed a significant decrease in DM intake with supplemental yeast culture. It was also found out that DM intake has decreased when brewer's yeast (Seymour et al., 1995) or live yeast (Wagner et al., 1990) was added to calves diets. Similarly to the present study, Magalhães et al. (2008) observed that incorporation of yeast culture (*Saccharomyces cerevisiae*) at 2% to the grain diet fed to the dairy calves between 2 to 70 days of life did not alter DM, protein and ME intake, feed efficiency and LWG.

In contrary to the present experiment, Magalhães et al. (2008) reported that calves fed yeast culture had decreased frequency of medical treatments because of reduced incidence of fever and diarrhoea and reduced overall morbidity. Also Kim et al. (2011) observed that calves from the hydrolysed yeast group showed better faecal and health scores after 3 weeks when compared with those in the control group. According to Chaucheyras-Durand et al. (2008), yeast responses vary depending on the strain of yeast used, the nature of the diet and the physiological status of the animal. Chaucheyras-Durand et al. (2008) concluded that the usage of supplemental yeast culture appears particularly relevant when the digestive microbiota is challenged, e.g., during a feed transition such as weaning, grazing, supply of high-concentrate diets, or during stressful periods, such as hot temperature or transportation. In dairy calves, Magalhães et al. (2008) concluded that under the conditions in which incidences of diarrhoea are high, yeast culture improves health of the digestive tract of young calves and reduces morbidity and mortality.

Conclusions

In conclusion, no treatment differences were observed in dry matter or energy intakes, liveweight gain, feed conversion ratio or health parameters of the calves in the present experiment. Based on earlier studies, it was hypothesized that *Saccharomyces cerevisiae* inclusion in a dairy calf starter would increase feed intake and improve growth and feed efficiency of dairy calves. However, the lack of differences in intake parameters and growth performance did not support this hypothesis. Thus, no evidence exists that *Saccharomyces cerevisiae* inclusion could have enhanced calf performance under the conditions of the present study. The calves in the present experiment were healthy; however different results might be observed in calves in altered physiological conditions.

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