EFFECTS OF SUPPLEMENTAL YEAST (*SACCHAROMYCES CEREVISIAE*) CULTURE ON RUMEN DEVELOPMENT AND GROWTH IN CALVES

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ABSTRACT. Effects of supplemental yeast (SACCHAROMYCES CEREVISIAE) culture on rumen development and growth in calves. *Yeast culture (Saccharomyces cerevisiae) was added to a calf starter at 0 (control), or 2% of dry matter to determine effects on intake, growth, and rumen development. Twenty Estonian Holstein calves (12 male and 8 female) were involved in the experiment at 5 days of age. Texturized calf starter and hay were offered ad libidum, and intake was measured daily. A subset of male calves was euthanized at 35 d of age and the other at 65 days of age for rumen epithelial growth measurements.*

Average final body weight of the control group was 90.59 kg, and that of the 2YC group 90.60 kg, the average daily gain of the control group during the first month was 384 g and that of 2YC group 348 g; during the second month it was 994 g and 1033 g, respectively. In the first month the dry matter intake of the control group was 1.25 kg/d and that of 2YC 1.22 kg/d, respectively, and in the second month 2.29 kg/d and 2.33 kg/d, respectively. It was not significantly affected by yeast supplementation in the starter ration.

Supplemental live yeast culture in the calf starter did not increase dry matter intake of the calves in the two first months of life.

In the second month of life, yeast supplementation slightly increased the daily gain of 2YC group and improved the usage of metabolizable protein, as compared to the control group.

The results indicate that calves receiving supplemental yeast (Saccharomyces cerevisiae) culture exhibited a slight improvement in rumen development parameters.

Key words*: yeast culture, rumen development, intake, calf*

Introduction

Yeast culture (*Saccharomyces cerevisiae*) has been shown several effects in ruminants. However, few studies have evaluated the effects of feeding yeast products to the diet of pre-ruminant and pre-weaning dairy calves. Including of live yeast in calf starter at levels 0.75%, 1.125%, 1.00% and 1.50% have increased feed intakes and daily gain but did not effect on the health of calves (Cole *et al*., 1992; Galvão *et al.*, 2005). There are no effects of yeast culture containing 0.2% of starter on feed intake, rates of gain or feed efficiency (Wagner *et al.,* 1990; Quigley *et al.,* 1992). Inclusion of yeast culture at 2% of the starter ration increased total dry matter intake, average daily gain, structural growth and slightly improves rumen development parameters in dairy calves (Heinrich, 2004; Lesmeister *et al.,* 2004a). Previous rumen development research has reported dry ration effects on rumen development parameters (papillae length and width, rumen wall thickness) but has focused on dietary physical form or dietary type (Stobo *et al.,* 1966, Nocek *et al.,* 1984; Kumar *et al*., 1997; Lesmeister and Heinrich, 2004b, Heinrichs, 2005). They reported the change of rumen pH, total ruminal VFA concentration, and ruminal butyrate and acetate production when included in calf solid feeds. Others have found age-related differences in rumen development parameters (Klein et al., 1997; Zitnan *et al.,* 1999). It is hypothesised that yeast (*Saccharomyces cerivisiae*) culture inclusion in a calf starter would aid rumen development and calf growth. Therefore, this trial was conducted to determine the effects of supplemental yeast culture in a dairy calf starter on feed intake and efficiency, daily gain and rumen development.

Material and methods

Twenty Estonian Holstein calves (12 male and 8 female) were separated from their dams shortly after birth, blocked by birth date and placed on experiment at 5 d of age. Calves were maintained on the study until 65 d of age. Calves were housed in individual pens. Growth parameter measurements were conducted monthly. The calves were weighed at 5, 35 and 65 d of age. Intake of starter, hay and milk replacer intake was measured daily. Composition of calf starter was similar between treatments with the exception of yeast culture content. Treatments consisted of a texturized calf starter containing 0% (control), or 2% (2YC) supplemental yeast culture as a percentage of starter DM. Starter contained 23% extracted soybean meal, 17% oats, 13% maize, 13% barley, 11% wheat, 10% wheat bran, 6% linseed cake, 3.3% rapeseed cake, 1.5% limestone and 2.2% mineral premix. All calves received colostrum and dams received milk twice a day. Calves received a 18.6% CP, 15.6% fat, and 16.9 MJ kg^{-1} DM milk replacer containing 50% whole milk powder, 3% dried

skimmed milk powder and 47% dried whey powder; and vitamin premix from 5 d of age until weaning. Milk replacer was provided in 2 equal feedings at 10% of body weight (BW) at the first month and 5% of BW at the second month of age. Texturized calf starter and hay were offered *ad libidum*, and intake was measured daily, beginning when calves were placed on the study. Water was provided free choice.

Starter and the other feeds samples analyzed for the content of DM, crude protein, crude ash, crude fibre, crude fat and minerals (AOAC, 2005). For determining crude ash concentration, samples were reduced to ashes in a furnace at 550^0C for 6 hours. Crude protein was analysed by the Kjeldahl method with the Kjeldec 2300 analyser (FOSS Tecator Technology), crude fat using a Tecator Soxtec System 2043 and crude fibre using a Tecator 1042 Hydrolyzing Unit System. The concentration of NDF and ADF in the samples was determined with a fibre analyser ANKOM 200 (Van Soest *et al*., 1991). Calf starter nutrient composition are presented in table 1. By design, nutrient composition was similar between treatments with the exception of yeast culture content.

Table 1. Nutrient composition of texturized calf starter containing 0 (control) and 2% supplemental yeast culture

Items	Control	2YC
Dry matter, %	88.8	88.5
In dry matter, g kg^{-1}		
crude protein	231	225
crude ash	105	76
crude fibre	90	90
NDF	219	220
ADF	88	88
crude fat	48	48
N-free extractives	526	561
metabolizable protein	115	117
metabolizable energy, MJ kg^{-1}	13.2	13.5
Saccaromyces Servisiae CBS 493.94, CFU kg^{-1}	0	4000

A procedure for rumen tissue sampling was developed to determine effects of supplemental yeast culture on rumen development and papillae growth in young calves. A subset of male calves was euthanized at 35 day of age and the other at 65 days of age for rumen epithelial growth measurements. Rumen sampling areas ($n = 6$) included the caudal dorsal sac left side, caudal dorsal sac right side and left side cranial ventral sac and right side and left side ventral portion of caudal ventral blind sac. (Lesmeister *et al.,* 2004). Three 1 cm^2 sections were removed from each area and measured for papillae lenght, papillae width, rumen wall thickness and number of papillae per cm^2. Correlations between areas, samples and measurements were obtained.

Experimental results were processed in a computer using a spreadsheet programme MS Excel. Variation statistics was used. Arithmetical means and standard deviation of the studied parameters were calculated. Significance of a difference between means was compared by *T*-test.

Results and discussion

Intake and BW gain. Table 2 presents least squares means for initial, in the middle, and final BW; average daily gain (ADG), and dry matter intake (DMI), metabolizable energy (MEI) and metabolizable protein (MPI) intake. Values for ADG, DMI are presented the first, the second and overall periods. Initial and final BW, therefore, daily gain and DMI, MEI and MPI were not significantly different between treatments. Although there were no statistically differences between average daily gain in the 1st and 2nd months and thoughout the experiment, it should be admitted that in the 2nd month the daily gain of the 2YC calves was by 39 g higher than that of the control group ($P = 0.739$).

Average daily gain during the first month for calves receiving the control and 2YC starter overall were lower than predicted by the model. However, actual the second month ADG was higher for all treatments than predicted by the NRC (2001) model.

In the first month, starter intake for calves receiving 2YC starter was 351 g per day and that for the control group 379 g per day, but in the second month it was 1219 g and 1174 g per day, respectively. Starter intake for calves receiving 2YC starter was higher in the second month compared to the control group calves, but no statistically significant differences ($P = 0.655$) were detected.

For every 1 kg of weight gain in the 1st period, the control group used 3.26 kg DM and 2YC group 3.51 kg; in the 2nd period the amounts were 2.30 kg and 2.25 kg, respectively. It was not significantly influenced by yeast supplementation in the starter ration. In the first period, the amount of MP for 1 kg weight gain for the calves of the control group was 410 g MP and for those of the 2YC group 445 g.

In the 2nd month, difference between the groups was not significant – 265 g and 261 g, respectively. In the 1st month, for 1 kg daily gain 45.5 MJ was used by the control group and 49.3 MJ by 2YC group; in the 2nd month 29.8 MJ and 29.5 MJ was used, respectively. Feed efficiency prior to weaning was not significantly influenced by adding yeast culture to the starter ration.

Results for DMI from the current study partially support the findings of Lesmeister *et al.* (2004) and Heinrichs (2004), who found numerically increased starter and total DMI prior to pre-weaning and weaning. Conversely, significantly higher starter and total DMI for calves receiving 2YC starter post-weaning and overall in the current study were in contrast to the results of Quigley *et al.* (1992), who indicated a significant decrease in DMI post-weaning and overall with supplemental yeast culture, when calves were fed for *ad libitum* consumption. In addition, others have found decreased DMI when brewer's yeast (Seymour *et al.*, 1995) or live yeast (Wagner *et al.*, 1990) was added to calf diets.

Table 2. Preweaning least square mean for intake and BW of Holstein calves receiving 0 (control) and 2% supplemental yeast culture in a calf starter

Items		Control	2YC
Body weight, kg			
Initial, 5 d	$\bar{x}$	49.27	49.16
	s	3.8	5.5
35 d	$\bar{x}$	60.78	59.61
	s	6.7	5.5
Final, 65 d	$\bar{x}$	90.59	90.60
	s	5.3	5.1
Daily gain, g d^{-1}			
6 to 35 d	$\bar{x}$	384	348
	s	157	132
36 to 65 d	$\bar{x}$	994	1033
	s	220	126
6 to 65 d	$\bar{x}$	689	691
	s	71	75
Dry matter intake, kg d^{-1}			
6 to 35 d		1.25	1.22
36 to 65 d		2.29	2.33
Metabolizable energy intake, MJ d^{-1}			
6 to 35 d		17.4	17.2
36 to 65 d		29.6	30.4
Metabolizable protein intake, g d^{-1}			
6 to 35 d		157	155
36 to 65 d		263	269

Rumen development. Average development parameters for ruminal epithelium and papillae – papillae length (PL), papillae width (PW), rumen wall thickness (RWT) and number of papillae per m^2 (NP) – from calves of different age, used to determine the effects of yeast culture on rumen development, are presented in table 3.

Table 3. Least squares means for rumen development measurements for Holstein calves receiving 0 (control) and 2% (2YC) supplemental yeast culture in a calf starter

Items	Control	2YC	s
Papillae length, cm			
1st month	1,23	1,25	0.29
2nd month	1,28	1,29	0.14
Papillae width, cm			
1st month	0,72	0,79	0.06
2nd month	0,91	0,94	0.03
Rumen wall thickness, cm			
1st month	1,39	1,40	0.30
2nd month	1,53	1,42	0.42
Number of papillae per cm^2			
1st month	37	41	1.31
2nd month	42	45	0.89

Figures 1 and 2 demonstrate the microrelief of ruminal pupillae of 2-month-old calves belonging to the control and 2YC groups. There were no significant differences among the groups of calves in rumen development parameters. However, compared to the 1-month-old calves, the papillae length of 2-month-old calves was greater by 4% (C) and 3% (2YC) and the papillae width greater by 21% (C) and 16% (2YC). The increase of rumen wall thickness from the first to the second month of age was 9% for the control group calves and 2% for 2YC calves. Compared to the calves of the control group, the number of papillae was by 10% greater for 2YC group calves in the1st month of age and by 7% greater in the 2nd month. From the first to the second month of age, the number of ruminal papillae increased by 12% (from 37 to 42) in group C and by 9% (from 41 to 45) in group 2YC (Table 3).

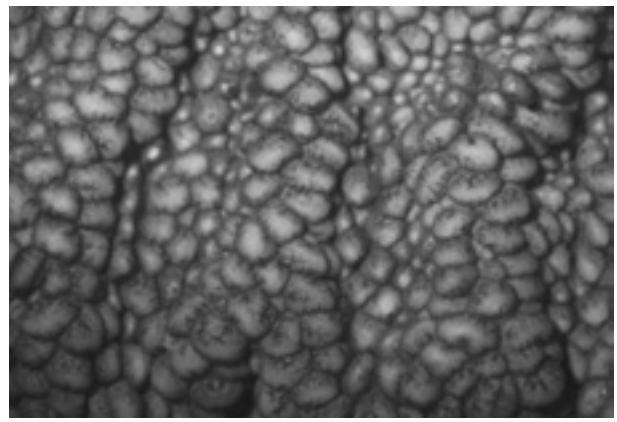

Figure 1. Microrelief of the dorsal rumen sac of 2YC group calf of 2 month of age. Magnification 12,5 x.

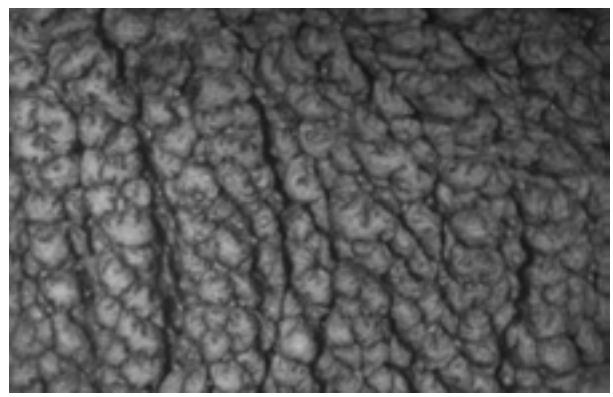

Figure 2. Microrelief of the dorsal rumen sac of controll group calf of 2 month of age. Magnification 12,5 x.

Papillae length and width are the most obvious factors influencing absorptive surface area, but changes in papillae density should also be considered. Dietary and age differences have been found to alter papillae density of the developing rumen, however, significant differences due to dietary treatment are seldom reported for papillae density in calves (Zitman *et al.,* 1998; Zitman *et al.,* 1999; Lane *et al.,* 2000; Lesmeister *et al.,* 2004a; Heinrichs 2005). Papillae density is commonly reported as the number of papillae in a fixed area regardless of rumen volume, but rumen volume has been shown to increase with age (Stobo *et al.,* 1966a).

Numerous researchers have indicated that ingestion of dry feed, and the resultant microbial end products, sufficiently stimulates rumen epithelial development but has focused on dietary physical form or dietary type (i.e., concentrates vs. forage) (Stobo *et al.,* 1966a; Nocek *et al,* 1984; Greenwood *et al.,* 1997; Lesmeister and Heinrichs, 2004).

Recent studies have looked at effects of dietary alterations or additions on rumen development and subsequent effects on rumen microbial end products. Additions of yeast culture increased grain intake by calves, and had marginal affects on rumen development in young calves when added at 2% of the diet (Lesmeister *et al.,* 2004b).

Conclusion

Supplemental live yeast culture in the calf starter did not increase dry matter intake of the calves in the first two months of life. In the second month of life, yeast supplementation slightly increased the daily gain of 2YC group and improved the usage of metabolizable protein, as compared to the control group.

The results indicate that calves receiving supplemental yeast (*Saccharomyces cerevisiae*) culture exhibited a slight improvement in rumen development parameters.

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Pärmiga (*Saccharomyces cerevisiae*) starteri söötmise mõju vasikate kasvule ja vatsa arengule

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Uurimistöösse valiti kaks analoogset rühma Eesti holsteini tõugu viie päeva vanust vasikat, kokku 12 pullikut ja 8 lehmikut. Katse kestis 60 päeva. Katsevasikaid kaaluti katse alguses, s.o 5 päevat, siis 35. päeva ja 65. päeva vanuselt ning arvestati ööpäevased juurdekasvud. Katseloomi peeti individuaalboksides. Söödad, hein, starter ja täispiimaasendaja anti individuaalselt, jäägid kaaluti iga päev. Pärmikultuuri (*Saccharomyces cerevisiae*) lisati vasikate starteri koostisse 2% kuivaines. Starterit ja heina said katseloomad isu järgi, täispiimaasendajat kaks korda päevas esimesel kuul arvestusega 10% kehakaalust ja teisel kuul 5% kehakaalust. Neli pullikut tapeti 35 ja 65 päeva vanuselt, et uurida vatsa arengut. Vatsaproovid histoloogiliseks uuringuks võeti vastavalt Lesmeister jt (2004) poolt väljatöötatud metoodikale. Vatsast võeti viiest erinevast kohast koetükid prepareerimiseks, mis teostati EMÜ VL histoloogia laboris. Määrati vatsa hattude pikkust, laiust, vatsaseina epiteeli paksust ja hattude arvu ühel cm^2-l.

Katse lõpus kaalusid kontrollrühma vasikad keskmiselt 90,59 kg ja pärmirühma vasikad 96,60 kg. Nende keskmine ööpäevane juurdekasv esimesel kuul oli 384 g (K) ja 348 g (2PR) ning teisel kuul vastavalt 994 g ja 1033 g. Esimesel kuul oli kontrollrühmal kuivaine söömus 1,25 kg päevas ja pärmirühmas 1,22 kg päevas, teisel kuul vastavalt 2,29 ja 2,33 kg päevas. Tõenäost erinevust ei esinenud, kuigi kuivaine söömus oli teisel kuul 40 g võrra suurem.

Pärmikultuuri lisamine vasikate starterisse ei suurendanud sööda kuivaine söömust vasikatel esimesel kahel elukuul. Teisel elukuul suurenes küll veidi (39 g võrra) vasikate keskmine juurdekasv päevas, mis oli vastavalt 1033 g PR ja 994 g K rühmas ning paranes proteiini kasutamine.

Histoloogilised uuringud näitasid, et pärmi lisamine vasikate starterisse parandas veidi vatsa hattude arengut.