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Effect of Applying Exogenous Polysaccharidases to Calf Starter on Feed Intake, Nutrient Digestibility and Growth Performance of Dairy Calves.

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ABSTRACT

Eighteen 1-d old dairy calves (47.9 ± 2.5 kg body weight; mean ± SD) were monitored for 3 28-d (84 d) to assess the effects of exogenous cellulases and xylanase applied to calf starter on nutrient digestibility and growth performance. Treatments included the starter with: 1) no enzyme (C), 2) enzyme A (EA, 0.6 ml/kg starter), and 3) enzyme B (EB, 1.9 ml/kg starter). The activity of exo-cellulase, endo-cellulase, and xylanase (μmol/ml/min) were respectively 1437, 788 and 7476 for enzyme A, and 1446, 1350 and 509 for enzyme B. No enzymes were added to the post-weaning diet. Polysaccharidases did not affect feed intake and efficiency, body weight, and average daily gain. Apparent digestibility of NDF and ADF at 28 d of age was improved in calves on EA as compared to control calves. Post-weaning digestibility of NDF and ADF was greater in calves on control diet than in calves that had been fed the enzyme treated starter before weaning. Positive pre-weaning and negative post-weaning response in fiber digestibility to pre-weaning use of fibrolytic enzymes in calf starter in this study, suggest the necessity of future studies using both cell-content and cell-wall polysaccharidases to further investigate the commercial potential of the exogenous enzymes in enhancing calf performance.

(**Key words:** exogenous polysaccharidase, starter diet, growth rate, dairy calves)

Abbreviation key: AIA = acid insoluble ash, **APL =** animal production level, **C =** control diet (calf starter with no enzyme supplementation), **EP =** exogenous polysaccharidases.

Introduction

Apparently, no or little inclusion of forage-fiber in pre-weaning calf diets has attracted much less attention to the use of **EP** for young calves. This, however, may not explain

overlooking a desperate need for more efficient utilization of non-forage soluble and insoluble polysaccharides by young dairy calves.

Young calves possess limited activity of enzymes degrading starch and cell-wall polysaccharides (Van Soest, 1994). Sufficient supply of volatile fatty acids from microbial fermentation is, on the other hand, crucial for proliferating development of the rumen epithelia and a shift in hepatic metabolism (Baldwin et al., 2004). These highlight the significance of a quick establishment and stress-free induction of fibrolytic and amylolytic capacities in the rumen and small intestine, respectively. To the authors' knowledge, there is no documented research on the use of **EP** in calf starter diet. The objective of this study was to determine the effect of applying the **EP** to the pre-weaning starter diet on pre- and post-weaning performance of dairy calves.

Materials and Methods

Eighteen (9 male and 9 female) 1-d old Holstein dairy calves (body weight, BW = 47.9 ± 2.5; mean ± SD) were monitored for 84 d at dairy facilities of Lavark Research Station (Isfahan Univ. Technol., Isfahan). Upon separation from dam shortly after calving, calves within each sex were assigned randomly to one of 3 treatments in a completely randomized design, and transferred into individual calf stalls bedded with clean wheat straw. As a result, 6 calves including 3 males and 3 females were allocated to each treatment. Calves were offered milk (10% of BW) twice daily at 0800 h and 1500 h for 49 d. From 49 to 55 d, daily offer of milk was halved and calves were weaned at 56 d. A calf starter concentrate (Table 1) was offered *ad libitum* for the entire experimental period (84 d).

Experimental treatments were, 1) control (starter with no enzyme additive), 2) starter supplemented with enzyme additive A (Pro-Mote®, Biovans Technologies Inc., Omaha, NE; 0.6 ml/kg DM of starter), and 3) starter supplemented with enzyme additive B (Biozyme MT-4000 Finnfeeds International Ltd., Malborough, UK; 1.9 ml/kg DM of starter). Both enzyme additives (EA and EB) were analyzed for the activity of exo-cellulase, endo-cellulase, and xylanase according to Mandel and Weber (1969), using 3,5-dinitrosalicylic acid as indicator. Each unit of enzyme activity was measured as the micromoles (μmol) of reducing sugars released from 1 ml of the enzyme per min. The activity of exo-cellulase, endo-cellulase, and xylanase were

respectively 1437, 788, and 7476 μmol/ml/min for EA, and 1446, 1350, and 509 μmol/ml/min for EB. Liquid enzyme supplements were diluted in distilled water (1:10 ratio of enzyme to

Table 1. Feed ingredients and chemical composition of the calf starter concentrate (DM basis).

Ingredients	% of dietary DM
Barley grain	56.0
Whole linted cottonseed	8.0
Cottonseed meal	8.0
Soybean meal	26.0
Minerals and vitamins supplement[1]	1.0
Sodium chloride	1.0
Chemical composition	
DM (%)	93.1
ME (Mcal/kg) [2]	3.13
NEm (Mcal/kg) [2]	2.35
NEg (Mcla/g) [2]	1.78
CP (% DM)	19.4
ADF (% DM)	13.4
NDF (% DM)	25.0
NFC [3] (% DM)	47.5
Ether Extract (% DM)	3.6
Ash (% DM)	4.5

[1] Contained 250000 IU vit. A, 50000 IU vit. D, 1500 IU vit E, 2.25 g Mn, 7.7 g Zn, 20 g P, 20.5 g Mg, 186 g Na, 1.25 F, 3 g S, 14 mg Co, 1.25 g Cu, 56 mg I, and 10 mg Se per kg supplement.

[2] Calculated from NRC (2001).

[3] Nonfiber carbohydrate = 100 – (NDF + CP + EE + Ash).

water) before spraying onto the calf starter at 1 h prefeeding every morning until 56 d of age, when calves were weaned. Control starter was similarly treated with water but without enzyme

additive. No enzyme additives were added to the calf starter after weaning. Performance criteria were measured repeatedly for each calf in 4-wk intervals at 28, 54, and 84 d of age.

Calves were weighed at 0800 h for two consecutive days after feed was nocturnally withheld for 12 h, at the end of each 4-wk interval. The ADG for each calf in each 4-wk interval was calculated by dividing the total BW gain during each period by the number of days (28). Normality of distribution and homogeneity of variance for residuals were ensured before conducting ANOVA. Data were analyzed as a mixed model for repeated measures (Wang and Goonewardene, 2004) using MIXED Procedure of SAS Institute (1996) with week as repeated factor.

Results and Discussion

Daily DMI of calves across 3 4-wk periods was not affected ($P > 0.05$) by application of **EP** to the starter diet (Table 2). This concurs with Krause et al. (1998) who observed no effects of fibrolytic enzymes applied to barley grain-based diets fed to growing steers. Similarly, Beauchemin et al. (1997) reported no feed intake response to two mixtures of exogenous cellulase and xylanase in beef cattle fed 90% barley grain. McAllister et al. (1999) did, however, notice a quadratic response in DMI of backgrounding steers to dietary treatment of fibrolytic enzymes. Feed efficiency, or the ratio of ADG to average daily DMI, was not changed by any of treatments ($P > 0.05$, Table 2). In other studies (Beauchemin et al., 1997; Iwaasa et al., 1997) an improvement in feed efficiency of feedlot cattle receiving barley-based diets has been reported. More digestible nature of the calf starter than that of diets for adult ruminants in addition to the low level of intake in young calves may explain the less sensitivity of their response to dietary treatment, particularly prior to weaning.

Calves in the current study were weighed after 12 h feed withdrawal at the end of each 28 d. This was to minimize the confounding from gut-fill. In the view of the fact that the effect of gut-fill on actual changes in body weight is usually a main concern in adult lactating ruminants as compared to young, non-lactating animals (Morris et al., 1999), no considerable impact of gut-fill on BW and ADG of calves were expected. BW of calves receiving different starters was similar ($P > 0.05$). This was in agreement with Beauchemin et al. (1997) who did not find any differences in BW of feedlot cattle on barley grain-based diets supplemented with **EP**.

Treatments did not affect ADG across both sexes and three periods (Table 2). No impact of **EP** on ADG has also been reported by others (Beauchemin et al., 1997; ZoBell et al., 2000),

using high-concentrate diets that seem to be associated with more consistent animal response as compared to forage-based rations (Beauchemin et al., 2003). A glimpse into the current literature could highlight the fact that the improved ADG of growing and finishing cattle resulted by **EP** supplementation of the diet were associated with high **APL** i.e. high ADG (1.5 kg/d, Beauchemin et al., 1995; 1.53 kg/d, Beauchemin et al., 1999; 2.1 kg/d, Iwaasa et al., 1997; 1.4 kg/d, McAllister et al., 1999). Calves in the current study had an ADG of 98, 634, and 814 g/d at 4 wk, 8 wk, and 12 wk of age, respectively. The low level of ADG, especially prior to weaning beside the use of only cell-wall **EP** may provide an APL-wise nutritional ground to explain the non-significant calf response to **EP** in the current study.

Apparent total tract digestibility of DM and OM in pre- and post-weaning calves were not influenced ($P > 0.05$) by the use of **EP** in the calf starter. This was in concurrence with Hristov et al. (2000) who reported no effects of dosing **EP** into the rumen on apparent digestibility of DM, CP, and NDF. Application of EA to the calf starter enhanced apparent digestibility of NDF and ADF ($P < 0.05$) at wk 4 but not at wk 8, in the present study (Figure 1 a, b). Thus, it can be inferred that both cellulose and xylans should have been effectively targeted by the **EP** at wk 4. Surprisingly, NDF and ADF digestibility at wk 12 (4 wk after stopping dietary inclusion of **EP**) was lower in calves that had been fed the enzyme supplemented starters before weaning as compared to those on control starter (Figure 1a,b). Results suggest that pre-weaning application of exogenous cell-wall polysaccharidases to the starter diet may improve fiber digestibility in dairy calves. Such pre-weaning improvement did, however, not lead to an enhanced growth performance, and was followed by a depressed fiber digestibility at 84 d in this study.

Table 2. Effect of exogenous polysaccharidases in calf starter on dry matter intake (DMI), feed efficiency, body weight (BW), average daily gain (ADG) and nutrient digestibility in calves during 3 4-wk periods (1-84 d of age)[1,2].

	Week 4			Week 8			Week 12				Effect, *P* =		
Item	C	EA	EB	C	EA	EB	C	EA	EB	SEM	T	W	T × W
BW, kg	50.7	50.1	51.4	67.7	67.4	70.3	90.6	89.8	93.4	2.3	ns	***	ns
ADG, g/d	102	68	123	606	620	675	818	798	826	37	ns	***	ns
DMI[3], g/d	377	346	374	1108	1097	1135	2280	2323	2272	25	ns	***	ns
Feed efficiency[3]	0.26	0.18	0.33	0.54	0.56	0.59	0.36	0.34	0.36	0.05	ns	***	ns
Apparent total tract digestibility, %													
DM	73.4	75.0	75.2	85.1	83.6	82.1	85.1	82.0	81.8	1.2	ns	***	0.14
OM	74.1	75.8	75.7	86.1	84.4	83.1	85.7	82.5	82.3	0.7	ns	***	0.12
NDF	48.7^{b}	57.5^{a}	47.1^{b}	73.9	69.2	67.5	66.9^{a}	54.9^{b}	52.3^{b}	2.5	*	***	**
ADF	48.1^{b}	58.7^{a}	52.8^{ab}	69.5	62.1	61.6	67.2 ^{a}	54.1^{b}	52.4^{b}	2.8	0.1	***	***
Ash	57.3	57.5	64.1	63.7	66.7	59.6	72.4	72.3	71.0	3.6	ns	***	ns

[1] Calves were weaned at wk 8 (56 d) and offered the calf starter for the entire experimental period (84 d). C = control group (no enzyme), EA = enzyme A supplemented starter with activity of 1437, 788, and 7476 μmol/ml/min for exo-cellulase, endocellulase, and xylanase, respectively, EB = enzyme B supplemented starter with activity of 1446, 1350, and 509 μmol/ml/min for exo-cellulase, endo-cellulase, and xylanase, respectively.

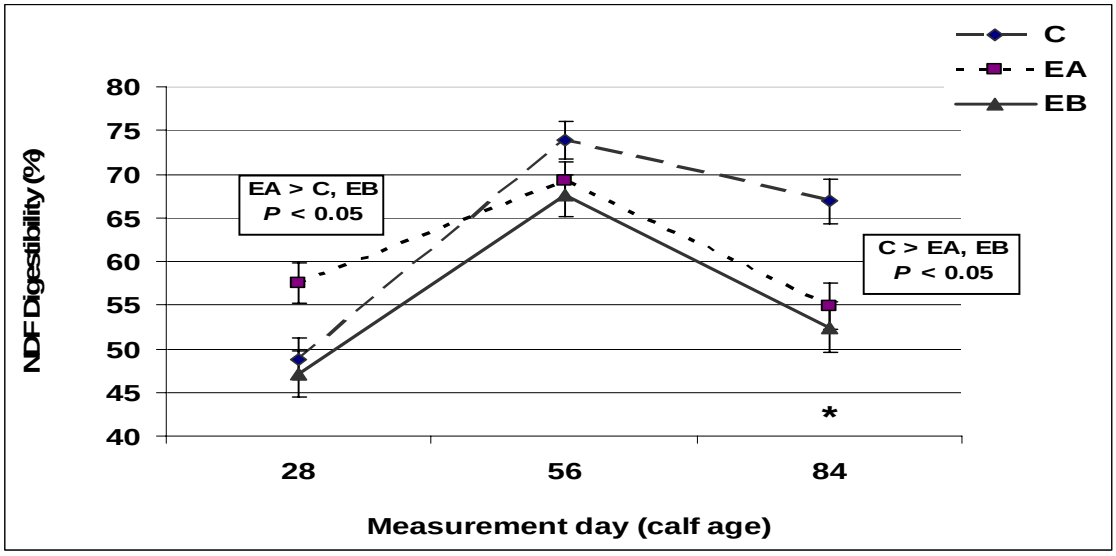
[2] Enzyme additives were diluted and sprayed onto the calf starter 1 h prefeeding. No enzyme additives were added to the starter after weaning.

[3] The ratio of ADG to DMI.

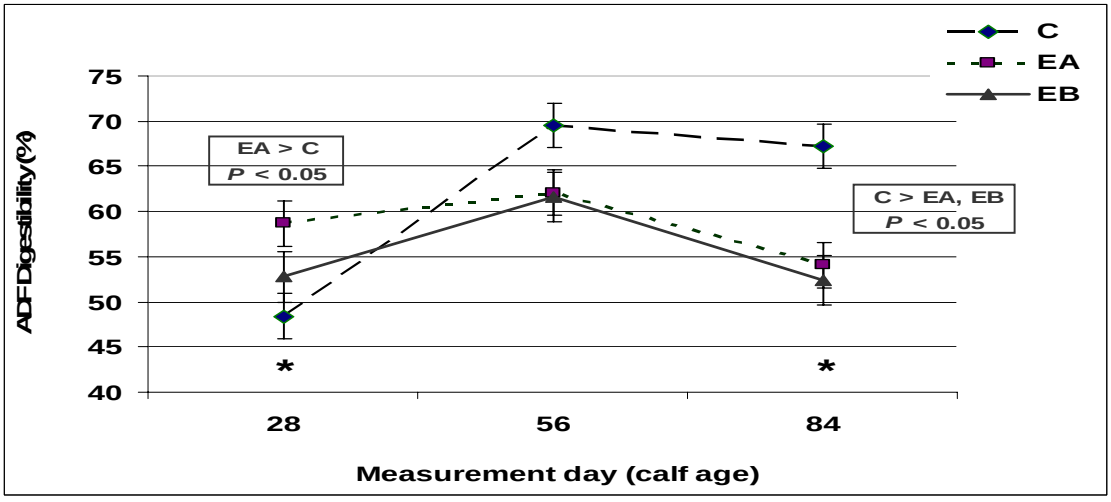
[a,b] Values with different superscripts in each row and within each week differ significantly ($P < 0.05$). * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.0001$. ns = not significant, $P > 0.15$.

[3] Daily intake of the starter concentrate.

T, treatment; W, week.



(a)



(b)

Figure 1. Apparent total tract digestibility of NDF (a) and ADF (b) in calves fed control **(C)** starter (no enzyme), enzyme A supplemented starter **(EA)**, and enzyme B supplemented starter **(EB)**. Respective enzyme activity (μmol/ml/min) of exo-cellulase, endo-cellulase, and xylanase were 1437, 788, and 7476 for EA; and 1446, 1350, and 509 for EB. Enzyme additives were diluted and sprayed onto the calf starter 1 h prefeeding. Calves were weaned at 56 d of age, and no enzyme additives were added to the starter after weaning.

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