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Effects of Feeding Regime Without Roughage on Performances and Rumen Development of Calves During Preweaning Period

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ÖZET

The objective of the study was to investigate the effect of only concentrate diet on growth and rumen development of Holstein calves during preweaning period. Thirty female and nine male calves were allocated to three treatments. Nine male calves were also divided into three treatments to operate for rumen wall samples. First group was fed with a calf starter and alfalfa hay as free choice, second group was received calf starter only and third group were fed with a total mixed ration (TMR) during the pre-weaning period. The average daily gain of the free choice, calf starter only and total mixed ration groups were 528.39±29.82, 509.00±34.08 and 479.21±25.86 g respectively. The average daily feed intake of the groups were 672.75±69.86, 619.73±77.75 and 499.60±81.69 g respectively. Calf starter group showed similar performances to free choice and TMR group of calves (P>0.05). Protozoa number were not significantly different among the treatments while total bacteria numbers were higher for calf starter group than the other two groups (P<0.05). The calves received calf starter only had flatter and more branched papillae than did the other calves. These results revealed that it is possible to rear calf successfully without roughage during preweaning period.

Keywords: Roughage; Rumen; Calves; Development; Histology

Sütten Kesim Öncesi Dönemde Kaba Yem Kullanmadan Beslemenin Buzağıların Performansı ve Rumen Gelişimi Üzerine Etkileri

ESER BİLGİSİ

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ÖZET

Bu çalışmada, sütten kesim öncesi dönemde sadece kesif yemle büyütmenin Holştayn buzağıların büyüme ve rumen gelişimi üzerine etkilerinin ortaya konulması amaçlanmıştır Çalışmada 30 dişi, ve rumen doku örnekleri almak için 9 erkek buzağı 3 muamele grubuna dağıtılmıştır. Birinci grup başlangıç yemi ve yonca kuru otunu serbest seçenek (tercihli) olarak almış, ikinci grup sadece buzağı başlangıç yemi ile yemlenmiş, üçüncü grup ise buzağı başlangıç yemi ve %10, 1-2 cm boyutunda öğütülmüş yonca ile hazırlanan toplam yem karışımı (TMR) ile yemlenmiştir. Ortalama günlük canlı ağırlık artışları tercihli grup, sadece buzağı başlangıç yemi alan grup ve TMR grubu için sırasıyla 528.39±29.82, 509.00±34.08 ve 479.21±25.86 g gün^{-1} olarak saptanmıştır. Grupların ortalama yem

tüketimleri yine aynı sırayla 672.75±69.86, 619.73±77.75 ve 499.60±81.69 g gün^{-1} olarak saptanmıştır. Sadece başlangıç yemi alan grup, tercihli grup ile TMR grubu buzağıların performanslarına benzer performans göstermiştir (P>0.05). Rumendeki bakteri sayısı sadece kesif yem alan buzağılarda diğer buzağılardan daha yüksek olarak saptanırken (P<0.05), rumendeki protozoa sayısı bakımından gruplar bir farklılık sergilememiştir. Sadece başlangıç yemi ile beslenen buzağılar diğer iki grubunkinden daha düz ve daha dallanmış rumen papillalarına sahip olmuşlardır. Bu çalışmada elde edilen sonuçlar, sütten kesim öncesi dönemde kaba yem kullanmadan sadece kesif yemle buzağı büyütmenin başarılı sonuç verebileceğini göstermektedir.

Anahtar sözcükler: Kaba yem; Rumen; Buzağı; Gelişme; Histoloji

1. Introduction

The future of any dairy farm depends on the successful rearing of calves and heifers for herd replacements. Rumen development in calves is important for the ability to digest solid feeds and to reduce their nutritional dependence on milk. Assisting a calf to eat solid feeds (e.g. concentrate, roughage) can have dramatic and positive effects on the process of rumen development (Jones & Heinrichs 2007). The transition from pre-ruminant to ruminant is not instantaneous, as adult volatile fatty acid (VFA) and amino acid profiles may develop over at least a week post-weaning (Quigley 1997), and rumen epithelial development and the ability of peripheral tissue to metabolize ketones may take 3 to 5 weeks (Warner 1991) as well. Early studies (e.g. Lengemann & Allen1959; Davenport 1987) showed that normal health is difficult to maintain in young ruminants without adequate roughage in the diet. Several researchers have recommended the addition of ground hay to the starter for optimum rumen development (Anderson et al 1987; Beharka et al 1998; Coverdale et al 2004; Greenwood et al 1997; Waterman 2005). However some researcher and extentionists (Harris &Sheare 2003; Jones & Heinrichs 2007; Heinrichs & Lesmeister 2000) reported that hay is not recommended for calves until weaning time when calves weaned 3-6 weeks, since it is less energy dense per unit than grain. Grain and calf starter is more efficient to improve ruminal epithelial growth compared to roughage (Nocek & Kesler 1980; Suearez et al 2007) and the roughage intake is very limited when the calves weaned early (e.g. 5 weeks). Calf rearing without roughage may be advised in early weaning practice but the calves are weaned at 8-10 weeks in calf rearing practice in Turkey and this suggestion has been made by some extentionists for our dairy farm as well. This suggestion should be tested under longer weaning practice than 35 days and this study was, therefore, to investigate the effect of feeding regime without roughage on growth performances of calves during preweaning period .

2. Materials and Methods

Thirty female and nine male Holstein calves born between September and November in the Research and Practice Farm of the Faculty of Agriculture, Çukurova University, Adana, Turkey were used for this study and were allocated into three experimental groups with similar birth weights. Nine male calves included to the experiment because of the rumen histological evaluation which was planned to operate for histological evaluation. One group was fed with a total mixed containing calf starter (90%) and alfalfa hay ground to 1–2 cm length (10%) (TMR), a second was fed with a calf starter and alfalfa hay as free choice, and the third group received only calf starter throughout the pre-weaning period. All calves were kept together with their mothers for the first 3 days after calving and then were housed in calf hutches (106 width × 118 length × 140 cm height) with individual paddock (136 width × 120 lenght × 90 cm height). All hutches had soil floors with a straw bedded which is commonly used in intensive dairy farm for calf comfort. Calves were fed colostrums as soon as possible after birth during the 3-day period. Between day 4 and 56, calves were fed with whole milk from a pail twice a day, such that each calf received 212 L whole milk (4 kg per day) over the whole experiment. Water was provided in the bucket used for the milk feeding. All calves were

fed *ad libitum*. All calves were weighed weekly, and daily records of feed consumption were kept during the 8-week experimental period. The chemical composition of calf starter and alfalfa hay is given in Table 1. The dry matter, crude protein, ash, ether extract and crude fiber contents of feeds were determined according to the standard AOAC procedures (1998). NDF and ADF were analyzed using the methods of Van Soest et al. (1991) with ANKOM fiber analyzer.

Table 1-Chemical compositions of starter feed and alfalfa hay
Çizelge 1-Başlatma yemi ve yonca kuru otunun kimyasal bileşimleri

Ingredients	g kg^{-1}	
Corn bran	400.00	
Wheat middlings	200.00	
Wheat bran	162.84	
Corn	100.00	
Corn gluten meal, 55%	85.54	
Hydrogenised fat	19.69	
Limestone	22.16	
Salt	8.06	
Vit. min. premix*	1.00	
Lasolocid sodium	0.70	
Chemical composition (%, as fed basis)	Starter feed	Alfalfa
Dry matter	93.87	93.24
Crude protein	16.77	11.60
Ether extract	4.14	0.80
Crude fiber	9.65	34.52
ADF	11.59	39.28
NDF	22.32	45.24
Ash	7.85	7.63
ME, Mcal kg^{-1}	2637**	1710***

*Kg Vitamin & mineral premix contains 15.000.000 IU vit A., 3.000.000 IU vit D3, 30.000 mg vit. E, 125.000 mg niacin, 50.000 mg Mn, 50.000 mg Fe, 50.000 mg Zn, 10.000 mg Cu, 800 mg I, 150 mg Co, 150 mg Se, 180.000 mg P, and:50.000 mg antioxidant
**Calculated according to the TSE (1991)
*** Calculated according to Undersander et al (1993)

Rumen tissue samples were taken from nine male calves fed in the same way as the experimental female calves. 9 male calves were subjected to an operation to get rumen tissues samples after completion of the experiment which performed by an experienced veterinarian. One-centimeter-square samples of the rumen wall tissues were taken from the dorsal part of the rumen and papillary growth was examined. Rumen fluid samples were taken from the rumen directly by using a vacuum pump from operated calves at 09:00 o'clock. Tissue samples were embedded in paraffin, cut into 5 µm sections and stained with Haematoxylin-eosin (HE) and Periodic Ascid Schiff (PAS). Measurements were taken using a Nikon Ocular micrometer under a Nikon eclipse E-200 light microscope. Histological observations of the samples taken from the rumen were also made. Papillae width (PW), papillae length (PL), submucosal thickness and muscularis mucosa thickness (RWT) were measured. Rumen pH as measured from the rumen fluid samples using a digital pH-meter (Sartorius, Pt-10P model) as soon as possible after taking samples. Protozoa numbers were determined by the modified methods of Dehority (1984) and total bacteria were counted according to Karahan et al (2002) at 40 × magnification by a light microscope.
Data related to live weight; daily gain, feed intake and feed to gain ratio, rumen histological measurements, pH, protozoa and bacterial count were analyzed according to the completely randomized design using the GLM Procedure in the SAS Program (1989). Means were separated by the Duncan Multiple Range Test.

3. Results and Discussion

The performance parameters of the experiment are summarized in Table 2. Feeding method did not affect feed intake, daily gain and feed to gain ratio ($P > 0.05$). Average daily weight gain values were ranged from 479 g to 528 during the entire experiment. Choice fed calves preferred a diet containing 97% calf starter and 3% alfa hay. Coverdale et al (2004) found that 7.5-15% ground grass hay (8-19 mm particle length) improved starter intake and daily gain compared to coarse or ground grain diets. Although there were no significant differences among treatments in respect

Table 2-The effect of feeding methods on calf performance
Çizelge 2-Yemleme metodlarının buzağı performansı üzerine etkisi

	Free-Choice	Calf Starter	Total Mixed Ration	*P* values
Birth weight, kg	34.59±1.54	34.86 ±1.39	35.36±1.27	0.93
Weaning weight, kg	64.18±2.53	63.37±2.01	62.20±1.70	0.81
Concentrate to roughage ratio	97/3¥	100/0	90/10	
Daily gain, g day^{-1}	528.39±29.82	509.00±34.08	479.21±25.86	0.53
Feed intake, g day^{-1}	672.75±69.86*	619.73±77.75	499.60±81.69	0.29
Feed to gain ratio*	1.27 ±0.99	1.19 ±0.10	1.02±0.14	0.32

¥ Hay to concentrate ratio is 97/3 which is calculated from alfalfa hay and starter preference of the calves
*Contains only dry feed

to feed intake. Choice fed calves (preferred a diet containing 3% alfalfa hay and calf starter groups consumed numerically 35% and 24% more feed compared total mixed diet containing 10% alfalfa hay. Similar trend was observed for daily gain as well. Although there was a trend ($P > 0.05$) to consume more feed and to gain more live, there are contradictory results in literature (Coverdale et al 2004). This could be attributed to difference between milk-fed periods between the studies. Shorter milk-fed period and early weaning may limit to consume roughage intake of calves. Roughage intake is about 10–15 g d^{-1} in the present study for the first 4-5 weeks when starter and alfalfa hay offered as choice. This could be, therefore, ignored and roughage may not be used in early weaning practice. On the other hand, the calves receiving starter only consumed satisfactory solid feed and gained satisfactory live weight compared to the calves fed total mixed diet and calves receiving calf starter+alfalfa hay as choice. Feeding all concentrate diet during preweaning period did not impair growing performance of the calves in the present study. Some researchers have recommended the addition of ground hay to the starter for optimum rumen development and performance (Anderson et al 1987; Greenwood et al 1997; Beharka et al 1998; Coverdale et al 2004; Waterman 2005), but some other researchers (Heinrichs & Lesmeister 2000; Harris & Sheare 2003; Jones & Heinrichs 2007) did not recommend hay during preweaning period, since it is less energy dense per unit than grain.

Feeding method had no effect on ruminal pH and protozoa ($P > 0.05$, Table 3). This could be attributed to the structure of calf starter, which is based on corn and wheat bran containing high fiber. Ruminal pH may play a role in the number of protozoa in the rumen, with marked decreases when rumen pH is lower than 5.5 (Yokoyama & Johnson 1988). Ruminal pH did not reach this critical point in the present study. However, feeding method significantly affected the number of bacteria ($P<0.05$). The calf fed with starter only had the highest number of bacteria (31.47±3.94) in the rumen. It is well known that ruminants are able to select their diet to meet their nutrient requirements and to minimize discomfort in their body and rumen (Görgülü et al 1996; Görgülü et al 2003; Görgülü et al 2008; Yurtseven & Görgülü 2004; Boga et al 2009). High concentrate diet can increase microbial growth due to availability of nutrient for microorganism (Demeyer & Van Nevel 1986; Leng 1990; Heinrichs & Jones 2010).

Parameters of the ruminal papillae did not differ ($P > 0.05$) according to the feeding methods, except for submucosa thickness (Table 4). As discussed

before, the structure of the concentrate (high bran content) and bedding material consumption may have masked the effects of high concentrate levels in the diets in terms of ruminal papilla growth. When the visual observations of ruminal papillae were evaluated, normal epithelial structure, minor inflammation and branching were generally detected in the three feeding methods. However the calves that received calf starter only had flatter and more branched papillae (Beharka et al 1998). High submucosa thickness of the calve receiving total mixed diet may be attributed to high acidity of rumen which causes high blood flow to tissues as well (Newbold et al 2004).

Table 3-Rumen pH, protozoa and bacterial counts of experimental groups
Çizelge 3-Deneme gruplarına ait rumen pH, protozoa ve bakteri sayıları

	Free-Choice	Calf Starter	Total mix Ration	*P* values
Rumen Acidity (pH)	6.14 ±0.14	5.98±0.78	5.86±0.34	0.87
Protozoa (10^6 ml^{-1})	25.92±1.60	32.21±2.79	31.98±3.91	0.43
Bacteria (10^9 ml^{-1})	21.95±0.42^{ab}	31.47±3.94^{a}	15.76±0.75^{b}	0.02

a, b: values with different superscripts indicate significant differences between groups

Table 4-Rumen wall tissue parameters of experimental groups
Çizelge 4-Deneme gruplarına ait rumen duvarı doku parametreleri

	n	Free-Choice	Calf Starter	TMR	*P* values
Papillae length, mm	3	19.66±1.47	18.00±1.38	18.66±0.83	0.14
Papillae width, mm	3	3.33±0.33	3.83±0.30	4.22±0.23	0.67
Muscularis mucosa thickness, mm	3	27.00±2.23	27.00±0.86	25.66±1.85	0.80
Submucosal thickness, mm	3	4.50±0.22^{b}	4.66±0.33^{b}	7.00±0.76^{a}	<0.01

a, b: values with different superscripts indicate significant differences between groups

4. Conclusions

These results suggested that feeding all concentrate diet did not impair ruminal growth and growth performance of calves during 8 weeks-preweaning period. However, further research is needed to determine the effects of all concentrate diet during preweaning period on the post-weaning performance of calves as there was no information about postweaning performance of the calves in the present study.

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