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Effects of Different Quality Roughage Supply on Performance of Holstein Calves during Preweaning Period

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ABSTRACT

The present study was conducted to investigate the effects of two different quality roughage (wheat straw and alfalfa hay) supplies on live weight gain, growth, feed intake and feed efficiency of Holstein calves during the preweaning period. With this purpose, 30 male and female Holstein calves were divided into two treatment groups (15 calves in each group) based on gender and birth weights. The first group was fed with a total mixed diet containing 80% calf starter and 20% alfalfa hay (chopped in 1-2 cm pieces) as a high quality roughage source and the second group was fed with a total mixed diet containing 80% calf starter and 20% wheat straw (chopped in 1-2 cm pieces) as a low quality roughage source during the preweaning period. The results revealed that feeding with high quality roughage (alfalfa hay) decreased feed intake ($P<0.05$) but didn't affect live weight and growth parameters ($P>0.05$) at the moment of weaning after 8 week preweaning period. Because of lower feed consumption without impairing calf performance and improved feed conversation efficiency, it can be suggested that high quality roughage could be supplied to calves in addition to calf starter feed during the preweaning period but meanwhile economic parameters like feed costs must be taken into account.

Keywords: Holstein; Calf; Weaning; Alfalfa; Wheat straw; Growth performance

Sütten Kesim Öncesi Dönemde Farklı Kalitedeki Kaba Yemlerle Beslemenin Holstein Buzağıların Performansı Üzerine Etkileri

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ÖZET

Bu çalışmada, Holstein buzağılarda sütten kesim öncesi dönemde iki farklı kalitedeki kaba yem kullanımının (kıyılmış halde kuru yonca otu ve buğday sapı) büyüme, gelişme, yem tüketimi ve yemden yararlanma özellikleri üzerindeki etkileri araştırılmıştır. Bu amaçla toplam 30 baş erkek ve dişi Holstein buzağı cinsiyet ve doğum ağırlıkları göz önünde bulundurularak her birinde 15 baş olmak üzere 2 deneme grubuna dağıtılmıştır. Birinci muamele grubunun % 80

oranında buzağı başlangıç yemi ve kaliteli kaba yem kaynağı olarak % 20 oranında 1-2 cm uzunluğundaki kıyılmış yonca kuru otu, ikinci muamele grubunun ise % 80 oranında buzağı başlangıç yemi ve düşük kaliteli kaba yem kaynağı olarak % 20 oranında 1-2 cm uzunluğundaki kuru buğday sapı kullanılarak hazırlanan toplam yem karışımını (TMR) 8 haftalık sütle besleme periyodu boyunca tüketmeleri sağlanmıştır. Çalışma sonucunda, buzağıların sütten kesim öncesi dönemde buzağı başlangıç yeminin yanında kaliteli kaba yemler ile beslenmesinin yem tüketimini azalttığı ($P<0.05$) ancak buna rağmen 8 haftalık süt ile besleme programı sonunda sütten kesim ağırlıklarını ve iskelet gelişimlerini etkilemediği ($P>0.05$) tespit edilmiştir. Bu noktadan hareketle, buzağıların performanslarının etkilenmeden daha az yem ile sütten kesilmelerine olanak sağlaması ayrıca yem çevirim kabiliyetlerini artırması ($P<0.05$) gibi faydaları göz önünde bulundurularak sütten kesim öncesi dönemde buzağıların kesif yeme ek olarak kaliteli kaba yemler ile beslenmesinin ekonomik faktörlerin de göz önünde bulundurulması koşuluyla uygun olacağı sonucuna varılmıştır.

Anahtar Kelimeler: Siyah Alaca; Buzağı; Sütten kesme; Yonca; Saman; Performans

1. Introduction

In dairy operations, proper growth and feeding of newborn calves are significant issues for replacing the dairy cows with the young ones. While milk constitutes about 60% of total facility income, calf and stock capital gain constitute 40% of total income. In other words, number of calves raised in the facility has a great impact on profitability of the operation (Erez 2011).

Including calves, proventriculus (rumen, reticulum and omasum) of young ruminants is not developed sufficiently during the initial periods of their lives. Early weaning without much influencing the calf performance may increase marketable milk production of the operation and protein supplements to the feeds cost less than the protein supplied with the milk (Turgut et al 1998). Thus, roughage and concentrate feeds should be used efficiently and proventriculus of calves should be developed as fast as possible to stimulate rumen development. Proventriculus development will be possible with the use of solid feeds (Göncü et al 2010). Several researchers indicated that roughages could be used for normal development of rumen throughout the preweaning period (Beharka et al 1998; Coverdale et al 2004; Waterman 2005; Van Ackeren et al 2009). Usage of roughages during the preweaning period may have stimulating impact on rumination (Lyford & Huber 1988), improve rumen action, volume and muscularity (Tamate et al 1962) and support epithelium and papilla development (Wardrop 1961). Parallel to this, some researchers have recommended the addition of roughage to the starter for optimum rumen development (Anderson et al 1987; Greenwood et al 1997), but some other researchers (Heinrichs & Lesmeister 2000; Lizieire et al 2002; Harris & Shearer 2003; Jones & Heinrichs 2007) did not recommend roughage during preweaning period. However, calf rearing without roughage was seen possible only for short-term weaning programs (<30 days) (Hibbs et al 1956; Leibholz 1975; Porter et al 2007).

It was indicated in studies investigating the effects of roughage forms of the ration that roughage forms did not have any significant impacts on growth performance of the calves (Leaver 1973; Kang & Leibholz 1973). It was also indicated in a previous study that wheat straw chopped at different lengths (1.5, 4.8 and 7.9 mm) did not yield significant differences in growth performance of calves (Pickard et al 1969).

Grass and legume hay and straw are common sources of fiber in the diet of the young calf. The quality of these forage sources greatly affects the palatability and the digestibility of the diet (Booth 2003). Differences in feed quality attributes were numerically assessed thorough relative feed value. Previous researchers investigated relative feed values of dry alfalfa hay and wheat straw (Yavuz 2005) and assessed digestibility and energy levels of different roughages (Denek & Deniz 2004). Güngör et al (2008) reported higher crude nutrient contents

for alfalfa than for wheat straw and indicated alfalfa as a quality roughage source.

There are several studies carried out about the effects of different preweaning milk feeding periods (Ozkaya & Toker 2012; Kocyigit et al 2015; Ayaşan et al 2015), feeding with roughage and without roughage (Göncü et al 2010; Daneshvar et al 2015) and different feed forms (Montoro et al 2013; Jahani-Moghadam et al 2015) and the studies about the effects of different roughage sources on calf performance have come into prominence (Zanton & Heinrichs 2009; Castells et al 2012; Terré et al 2013). However, despite all these studies, effects of roughage quality on calf performance are not clear, yet. Therefore, the present study was conducted to investigate the effects of roughage quality in 8 weeks preweaning period on calf performance.

2. Material and Methods

The present study was conducted with 30 Holstein calves in a livestock facility located in Kayseri province of Turkey (latitude: 38.73695, longitude: 35.49683). Two treatment groups were formed with 15 calves consuming poor and high quality roughage. Calves were tried to be placed in treatment groups as much equally as possible based on gender (8 males and 7 females in each treatment group), age (all of the calves were born from the mothers at the same age within 24 hours), amount of colostrum intake and live weight (Table 1). Experiments were implemented throughout 8 weeks of preweaning period. The first treatment group (dry alfalfa hay-DAH) was supplied with 80% calf starter feed obtained from a commercial feed factory in Kayseri and 20% dry alfalfa hay chopped at 1-2 cm pieces as a quality roughage source in addition to milk from the 14th day of birth. The second group (wheat straw-WS) was supplied with total mixed ration (TMR) composed of 80% calf starter feed and 20% dry wheat straw chopped at 1-2 cm pieces as a poor quality roughage source. All calves were fed *ad libitum*.

Calves were housed in individual pens throughout the experiments and straw bedding was used over pen floors. The calves stayed with their mothers in the first day. They took colostrum within maximum 2 hours from the birth and colostrum was supplied to calves for 3 days with a feeding bottle. From the 3rd day till weaning, the calves consumed a total of 4 liters whole milk (the average values obtained from the analyses performed on morning milk samples taken in every two weeks by using FOSS FT120 milk analysis device: fat 3.81%, protein 3.09%, lactose 4.49% and fat-free dry matter 8.19%) daily in two diets with a nipple bucket. All calves consumed a total of 212 liters milk throughout 8 weeks of milk-feeding period. Clean drinking water was supplied *ad libitum*.

Calves were weighed in every two weeks starting from the birth with an electronic scale (100 kg ± 0.001 kg) to calculate live weight gains. Feeds (hay and concentrated feed) were weighed every day to determine daily feed consumption of the calves. Skeletal growth was determined through measuring the chest girths, withers heights and hip widths in accordance with the methods specified in literature (Heinrichs & Lammers 1998). Feed conversion rates were calculated by dividing daily dry matter intake (g) with daily live weight gain (g). The changes in live weights were determined by subtracting birth weights from the live weights at the end of experiments (56th day).

Analyses of dry matter (DM), crude ash (CA), crude protein (CP) and crude fat (CF) contents of

Table 1- Birth weights and colostrum intake of calves

	Groups			
Parameters	*WS*	*DAH*	*SE*	*Significance*
Birth weight, kg	39.50	39.60	0.91	ns
Total Colostrum intake, L	16.30	16.80	0.95	ns

DAH, dry alfalfa hay; WS, wheat straw; SE, standard error; ns, not significant

roughage sources (wheat straw and alfalfa hay) were carried out in accordance with AOAC (1998); acid detergent fiber (ADF) and neutral detergent fiber (NDF) analyses were carried out in accordance with Van Soest et al (1991); metabolic energy (ME) and organic matter digestibility (OMD) values were calculated with the equation developed by Menke et al (1979) by using the amount of gases released after 24 hours fermentation through in vitro gas production technique. Rumen fluid was obtained from two fistulated sheep fed twice daily with a diet containing alfalfa hay (60%) and concentrate feed (40%). About 0.200 g dry samples were weighed in triplicate into the calibrated 100 mL glass syringes. The syringes were pre-warmed to 39 °C before the injection of 30 mL rumen fluid-buffer mixture into each syringe followed by incubation in a water bath at 39 °C. Readings of gas production were recorded before incubation (0) and 24 h after incubation.

The metabolic energy (ME) (Mcal kg^{-1} DM) of feedstuffs was calculated according to Menke et al (1979) (Equation 1).

$$ME = (2.20+0.1136\times GP+0.0057\times CP+0.00029\times CF2)/4.184 \quad (1)$$

Where; GP, 24 h net gas production (mL 200 mg^{-1}); CP, crude protein (%) and CF, crude fat (%).

The organic matter digestibility (OMD) of feedstuffs was calculated according to Menke et al (1979) (Equation 2).

$$OMD\ (\%) = 14.88+0.889\times GP+0.45\times CP+0.0651\times CA \quad (2)$$

Where; GP, 24 h net gas production (mL 200 mg^{-1}); CP, crude protein (%); CA, crude ash (%).

The equations specified by Van Dyke & Anderson (2000) were used determine relative feed value (RFV) (Table 2) of roughage sources used in experiments. Relative feed values were calculated by using digestible dry matter (DDM) and dry matter intake (DMI) values. Digestible dry matter was calculated by using ADF and dry matter intake was calculated by using NDF values. Results are provided in Table 2.

Table 2- Nutritive values and quality attributes of calf starter feed, alfalfa hay and wheat straw

	Feed materials		
Nutrients	*Calf starter feed**	*Alfalfa*	*Wheat straw*
Crude protein, %	18	18.06	3.74
Dry matter, %	88	91.72	90.14
Crude ash, %	8.00	9.78	8.02
Crude fat, %	3.60	2.52	1.49
ADF, %	18	36.09	52.37
NDF, %	30	44.41	80.14
ME, kcal kg^{-1}	2800	1810	1140
OMD, %	-	58.81	32.87
DDM, %	-	60.79	48.10
DMI, %	-	2.70	1.50
RFV	-	127.20	55.92

*, values were received from the producer; ADF, acid detergent fiber; NDF, neutral detergent fiber; ME, metabolic energy; OMD, organic matter digestibility; DDM, digestible dry matter= 88.9-(0.779xADF); DMI, dry matter intake= 120/NDF; RFV, relative feed value= DDMxDMIx0.775

Descriptive statistics for studied variables were presented as mean and standard errors. Experimental results were subjected to the independent samples t-test to determine whether or not the differences between the groups were significant. Significance level was considered as 5% and SPSS statistical software was used in all statistical analyses (SPSS 2002).

3. Results and Discussion

Daily feed consumption (DFC), initial live weights (ILW), mid-experiment (4^{th} week) live weights (MLW), final live weights (FLW), daily live weight gains (LWG), feed conversion ratios (FCR), initial chest girths (ICG), mid-experiment (4^{th} week) chest girths (MCG), final chest girths (FCG), initial hip widths (IHW), mid-experiment (4^{th} week) hip widths (MHW), final hip widths (FHW), initial withers heights (IWH), mid-experiment (4^{th} week) withers heights (MWH), final withers heights (FWH), changes in live weights (CLW), changes in chest girths (CCG), changes in hip widths (CHW) and changes in withers heights (CWH) of the calves fed with different quality roughages throughout 8 week preweaning period are provided in Table 3.

Table 3- Performance and growth parameters of calves

	Groups			
	WS	*DAH*	*SE*	*Significance*
Live weight				
ILW, kg	39.50	39.60	0.91	ns
MLW, kg	57.50	58.00	1.38	ns
FLW, kg	70.20	70.80	0.93	ns
LWG, g day^{-1}	548.21	557.14	1.08	ns
CLW, kg	30.70	31.20	0.33	ns
Feed consumption				
DFC, g day^{-1}	883.26	859.65	7.39	**
FCR, DFC LWG^{-1}	1.61	1.54	0.03	*
Chest girth				
ICG, cm	78.60	79.80	1.53	ns
MCG, cm	89.50	91.85	1.36	ns
FCG, cm	98.00	100.80	1.97	ns
CCG, cm	19.40	21.00	1.08	ns
Hip width				
IHW, cm	19.15	19.50	0.73	ns
MHW, cm	21.85	22.40	0.93	ns
FHW, cm	26.50	27.40	0.94	ns
CHW, cm	7.35	7.90	0.67	ns
Withers height				
IWH, cm	75.50	76.00	1.23	ns
MWH, cm	78.70	80.00	1.24	ns
FWH, cm	84.20	86.45	1.87	ns
CWH, cm	8.70	10.45	1.25	ns

DAH, dry alfalfa hay; *WS*, wheat straw; *SE*, standard error; *, < 0.05; **, < 0.01; ns, not significant; ILW, initial live weight; MLW, mid-experiment (4^{th} week) live weight; FLW, final live weight; LWG, live weight gain; CLW, changes in live weight; DFC, daily feed consumption; FCR, feed conversion ratio (contains only dry feed); ICG, initial chest girth; MCG, mid-experiment (4^{th} week) chest girth; FCG, final chest girth; CCG, changes in chest girth; IHW, initial hip width; MHW, mid-experiment (4^{th} week) hip width; FHW, final hip width; CHW, changes in hip width; IWH, initial withers height; MWH, mid-experiment (4^{th} week) withers height; FWH, final withers height; CWH, changes in withers height

The differences in initial, mid-experiment and final live weights, daily live weight gains, changes in live weights, initial, mid-experiment and final chest girths, changes in chest girths, initial, mid-experiment and final hip widths, changes in hip widths, initial, mid-experiment and final withers heights and changes in withers heights of experimental groups were not found to be significant (P>0.05). It was reported in previous studies (Greenwood et al 1997; Beharka et al 1998; Coverdale et al 2004; Suarez et al 2007; Castells et al 2012) that calf performance and live weights varied based on weaning age, type of roughage supply (*ad libitum* or TMR), form of roughage supply (hay or smaller pieces) and roughage (e.g., alfalfa hay, straw, grass hay, fresh grass, corn silage). In this study, similar growth performance and weaning weights of the calves fed with high

and low quality roughage were probably resulted from equal milk feeding (4 L day^{-1}) of treatment groups, relatively low ratios (20%) of roughage in TMR and relatively shorter treatment durations (14-56th days).

On the other hand, roughage quality had significant impacts on daily feed consumptions and feed conversion ratios ($P<0.05$). While the daily average feed consumption of the calves fed with alfalfa hay as a roughage was 859.65 g, the value was observed to be 883.26 g in treatment group fed with wheat straw ($P<0.05$). The calves fed with wheat straw throughout the preweaning period had higher feed consumptions than the calves fed with alfalfa hay. Complying with the findings of earlier studies (Beharka et al 1998; Booth 2003; Coverdale et al 2004; Suarez et al 2007), use of low quality roughage instead of high quality roughage in rations increased daily feed consumptions throughout the preweaning period. However, current findings conflict with those observed by Castells et al (2012) who observed greater DFC in calves fed with WS than DAH. However in that study, roughage was not supplied in TMR, they were supplied freely, thus the animals fed with WS consumed 5% roughage and the ones fed with DAH consumed 15% roughage. Therefore, the DGC values were higher than the present values. Since the wheat straw used in present study had 1.58% less dry matter content than alfalfa hay (Table 2), the difference in dry matter contents might have an increasing effect on feed consumption. Such a difference in feed consumptions might have also resulted from higher digestible nutrient content of alfalfa hay than wheat straw and consequently the calves fed with alfalfa hay was able to meet their nutritional needs with less feed consumption. Furthermore, increasing feed intakes with low quality roughage might be due to a bulky effect, which helps to stimulate rumination and improve rumen pH of young calves, instead of an increase of the NDF content of the diet (Booth 2003).

Feed conversion ratio of the treatment group fed with wheat straw (1.61) was higher than the ratio in alfalfa consuming group (1.54) ($P<0.05$). Lower feed conversion ratios indicate better conversions, in other words less feed consumptions for unit live weight gain. Accordingly, while the daily feed consumption of the treatment group fed with alfalfa hay (DAH) was 859.65 g and the daily live weight gain of the group was 557.14 g, the values were respectively observed as 883.26 g (DFC) and 548.21 g (LWG) in treatment group fed with wheat straw (WS). Complying with the earlier findings (Leaver 1973; Greenwood et al 1997; Booth 2003; Coverdale et al 2004), feed conversion ability of the calves fed with high quality roughage throughout the preweaning period was better than the calves fed with low quality roughage. Again higher digestible nutrient and lower NDF content of alfalfa hay than wheat straw (Table 2) resulted in higher nutrient intake in alfalfa consumed calves than in wheat straw consumed calves, thus better feed conversions in alfalfa group.

4. Conclusions

Current findings revealed that calf feeding with quality roughage throughout the preweaning period in addition to concentrate feed decreased the feed consumption of the calves ($P<0.05$). However such a feeding program throughout the 8 weeks of milk-fed period did not significantly influence weaning weights and skeletal development of the calves ($P>0.05$). It was concluded that quality roughage supply in addition to concentrate feed was found to be a convenient approach to allow weaning of calves with less feed consumption without impairing their performances and to improve feed conversion abilities of the calves in an economical fashion ($P<0.05$). The present study can be considered as an initial step for further studies and as an indicator for producer-level practices. There is a need for further studies to investigate the rumen development of calves reared with different quality roughages, to assess further performance of calves and to evaluate the effects on dairy and beef cattle separately.

Abbreviations and Symbols			
kg	kilogram	*FLW*	Final live weight
g	gram	*FCG*	Final chest girth
L	liter	*FHW*	Final hip width
mL	milliliter	*FWH*	Final withers height
m	meter	*CLW*	Changes in live weight
cm	centimeter	*CCG*	Changes in chest girth
mm	millimeter	*CHW*	Changes in hip width
DAH	Dry alfalfa hay	*CWH*	Changes in withers height
WS	Wheat straw	*ADF*	Acid detergent fiber
TMR	Total mixed ration	*NDF*	Neutral detergent fiber
ILW	Initial live weight	*OMD*	Organic matter digestibility
ICG	Initial chest girth	*ME*	Metabolic energy
IHW	Initial hip width	*DDM*	Digestible dry matter
IWH	Initial withers height	*DMI*	Dry matter intake
MLW	Mid-experiment live weight	*RFV*	Relative feed value
MCG	Mid-experiment chest girth	*FCR*	Feed conversion ratio
MHW	Mid-experiment hip width	*DFC*	Daily feed consumption
MWH	Mid-experiment withers height		

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