Bulgarian Journal of Agricultural Science, 21 (No 2) 2015, 384–393
Agricultural Academy

THE EFFECT OF FEEDING DIFFERENT MILK PROGRAMS ON DAIRY CALF GROWTH, HEALTH AND DEVELOPMENT

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Abstract

YAVUZ, E., N. TODOROV, G. GANCHEV and K. NEDELKOV, 2015. The effect of feeding different milk programs on dairy calf growth, health and development. *Bulg. J. Agric. Sci.*, 21: 384–393

Object of this study was to evaluate the effect of quantity and duration of milk feeding in the first two months of life of dairy calves on their growth and development until 70 days of age. The experiment was carried out from September to November. Average ambient temperature varied from 8 to 17°C. Calves were kept in individual hutches with straw bedding. Sixty Black and White female calves (mean 38.4 kg live weight) were included in a 70-day trial to evaluate the effect of three milk feeding programs. Calves were allocated to treatments based on weight and date of birth and blood immunoglobulin (Ig) concentration on 2 days of age.

Calves were fed pasteurized (60°C for 30 min) unsalable milk from antibiotic-treated cows at three levels:

- Low milk group (LM), totally 172 L to weaning on 49 days of age;
- Moderate milk (MM), 315 L milk to 56 days of age;
- High milk (HM) 416 L to weaning at 56 days.

All calves received 2 L high quality (above 50 g Ig/L) colostrum three times in the first day after calving, and medium or low quality colostrum, usually from second and third milking after calving, 3 times by 2 L during the second day of life. Calf starter with 19% crude protein (CP) consisting of 50% whole maize grain and 50% pelleted protein concentrate (29% CP) was offered free choice until 70 days of age to three groups of calves. Alfalfa hay was offered *ad libitum* after 35 days of age. Starter feed, hay and milk consumption were controlled on a daily basis during the trial. Live weight and size of calves were measured at birth, and at 35, 56 and 70 days of age.

Health status and behavior were observed every day. Beginning of rumination was observed and duration of rumination was recorded on 53–56 and 67–70 days of age. Intake of starter feed after 35 days of age depended on level of milk feeding, but did not compensate shortage of energy at any of experimental milk feeding levels. Dry matter intake (DMI), net energy (FUG) intake and live weight gain (LWG) until 35 days of age were different ($P < 0.05$) for groups of calves receiving 4, 6 or 8 L of milk. From 36 to 56 days of age starter DMI, FUG intake and LWG differed ($P < 0.05$) only between LM and HM groups. The dry mater conversion ratio was higher for HM than LM group until 35 days of age, but not later. There were no significant differences ($P > 0.05$) in FUG efficiency between groups during the different periods of the trial. Tendency for lower LWG after weaning of the HM group, compared to LM and MM groups was observed, which may be connected with lower digestibility of dry feeds or deposition of more fat into the body of calves.

Size growth followed LWG, but differences between groups of calves were significant only after 35 days of age for withers height, and after 56 days of age for heart girth. Rumination time differed between groups only at 53–56 days of age. There were no differences in diarrhea, pneumonia and other illness among the groups. Fecal scores tended to be low (softer) in HM group, and LM calves tended to have more non feeding oral behavior and bellowing compared to other groups. After weaning, the growth, health condition, rumination and feed efficiency were equal for the three groups of calves. In conclusion abundant

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colostrum and milk feeding resulted in significant advancing in live weight and frame size growth during the first 35 days of life, before rumen development and increased dry feed intake. The calves' performance and health status were not affected by the level of milk feeding during the preweaning period. Experimental calves will be followed through the first lactation to see if treatments had any marked effect on future milk production.

Key words: dairy calf, milk feeding, growth, health, development, feed efficiency, weaning check
Abbreviations: CP – crude protein, DM – dry mater, FUG – feed unit for gain, HM – high milk group, Ig – Immunoglobulin, LM – low milk group, MM – moderate milk group, LW – live weight, LWG – live weight gain

Introduction

Early weaning and restricted-milk feeding programs have been widely used as strategies to reduce feeding costs of rearing young calves. This can be achieved through encouraging early intake of dry feeds that stimulates the rumen development and allows achieving satisfactory growth and good health using less milk or milk replacer. However, research during the last decade has shown the advantages of providing more milk or milk replacer on improving calf growth, welfare, and future productivity (Khan et al., 2011a). Therefore, it is necessary to re-evaluate the effects of liquid and solid feeding on development of calves and their future production.

Appropriate and ample supply of nutrients for calves is essential for their performance and welfare. Recently, many attempts were made to improve the supply of nutrients to calves through greater offering of milk in more-frequent meals (Jasper and Weary, 2002; Khan et al., 2007a, b) during the first months of rearing calves. These programs have been called by a variety of names including accelerated, enhanced, and intensified feeding. The higher level of milk feeding for dairy calves has the potential to increase growth rates during the preweaning period (Jasper and Weary, 2002; Shamay et al., 2005; Kamiya et al., 2009; Uys et al., 2011), to reduce time needed to reach a necessary body weigh at first calving (Davis Rincker et al., 2006) and improve milk yield at first calving (Shamay et al., 2005; Drackley et al., 2007; Terré et al., 2009; Moallem et al., 2010; Soberon et al., 2012). Disadvantages of providing more milk include reduced solid feed intake during the milk feeding period (Terré et al., 2007; Weary et al., 2008; Uys et al., 2011; DePassille et al., 2011) and slower rumen development (Khan et al., 2007a,b). Additionally, more abundant feeding preweaning may be more stressful during transition from liquid to solid feed. On the contrary, inadequate nutrition can depress the immune function and thus increase the susceptibility to disease in calves (Nonnecke et al., 2003).

Kristensen et al. (2007) studied the effects of different milk feeding levels (3.1, 4.8, 6.6 and 8.3 kg/day of milk replacer) on calf performance and rumen development. They found that although calves reared on higher milk feeding levels had reduced solid feed intakes, the length of rumen papillae at 5 weeks of age was not affected by feeding treatment. Roth et al. (2009) found that the length of papillae in the atrium or ventral ruminal sac was not affected by milk allowance or by the resulting variation in solid feed consumption in calves.

There is evidence that step-down method of feeding calves allowed higher body weight gain and feed efficiency compared to equal rate of milk feeding during whole preweaning period (Niazi et al., 2010).

Castells et al. (2010) reported that calves receiving ryegrass hay consumed less hay (59 g/day), compared to alfalfa hay (144 g/day), but more starter (1.2 vs. 0.9 kg/day) and LWG until 57 days of age were equal. Total DM intake tended to be higher in calves fad ryegrass hay compared to calves without forage. Therefore, forage feeding may influence the effect of level of milk offering to calves. However, feeding forage to calves offered restricted amounts of milk has traditionally been discouraged because it could decrease voluntary intake of starter feed by a potential accumulation of undigested fiber in the rumen (Drackley, 2008).

Recent calf studies have shown that preweaning nutrient intake, from milk or milk replacer, can have profound effects on development of the calf that enhance first lactation and lifetime productivity. Data indicate that for every 100 g increases of preweaning LWG, first lactation milk yield increased by 155 kg (Soberon and Van Amburgh, 2013). There are many reports for the positive effect of so-called lactocrine effect of abundant milk or milk replacer feeding on future milk performance of heifer calves (Shamay et al., 2005; Drackley et al., 2007; Terré et al., 2009; Moallem et al., 2010; Soberon et al., 2011, 2012). However, there were inconsistencies between the various studies. Other trials have not reported differences of milk yield on first lactation of heifers fed more colostrum or milk as calves, compared to those fed less colostrum (Pithua et al., 2010; Ozer et al., 2012) or milk and milk replacer (Aikman et al., 2007; Raeth-

Knight et al., 2009). The contribution of colostrum and milk level of feeding, or higher LWG during the first 2 months of calf life independently of what type of feeding was applied on future milk production of female calves are not clear.

So far is it not clear, whether it is possible to combine intensive liquid feeding with sufficient dry feed intakes at weaning to continue normal growth of calves; otherwise, what is the level of milk feeding allowing small, or even to avoid, slump in growth at weaning. It is not known what level of milk feeding plus free access to starter allows obtaining a high level of live body gain during the first two months necessary for enhancing future milk yield of heifer calves.

The aim of the study was to estimate the effect of different levels of milk feeding to female dairy calves on growth rate, development, feed efficiency and health status during preweaning and post-weaning period. The intention is to continue the control of heifer calves and establish the impact of level of milk feeding on their future milk production.

Materials and Methods

Sixty, one day old female calves of Black and White breed are assigned in three experimental groups (20 calves each) equalized by weight at birth, parity of dam (first or second and more calving) and blood immunoglobulin (Ig) level at 2 days of age of experimental calves. All calves were housed in individual hutches (100 × 150 cm) bedded with straw. Experiment was carried out in September – November. Average ambient temperature varied from 8 to 17°C.

All calves received 2 L high-quality (above 50 g Ig/L) colostrum in three feedings (total 6 L) in the first 24 h. The second day they received 2 L in three feedings (total 6 L) of available colostrum, usually medium- or low-quality colostrum, from second and third milking after calving. After two days of age whole pasteurized unmarketable milk was provided in two feedings. Pasteurizations were conducted at 60°C for 30 minutes. According to Wilson and Rincker (2010) pasteurization of milk and colostrum did not change their immunoglobulin content and activities.

Treatments included feeding 4 L milk daily until 35 days of age for low milk group (LM), 6 L to 49 days for moderate milk group (MM), and 8 L to 49 days for high milk group (HM) respectively. Two weeks for LM group, and one week for MM and HM groups before weaning milk was reduced by 50% and offered in one feeding per day to promote increased starter intake. Total quantity of colostrum and milk fed per calf amounted respectively to 172, 315 and 416 L for LM, MM and HM groups (Table 1). Average milk dry mater, fat and protein content from weekly measurements were 12.46%, 3.82% and 3.23% respectively. One kilogram DM of milk and colostrum has 2.327 FUG according to Todorov et al. (2007).

Complete weaning was done as planned on 49 days of age for LM group and on 56 days of age in MM and HM groups. At weaning the consumption of calf starter exceeded 1% of body weight for at least three consecutive days in all calves.

In addition to liquid feed all calves from the three group received *ad libitum* the same calf starter with 19 % crude protein (CP) consisting of 50% whole maize grain and 50% pelleted protein concentrate (Table 2) from 3 days of age until 70 days of age (end of first stage of experiment). Feeding texturized starter consisting of whole grains and pelleted protein concentrate ensured good LWG and rumen papillae development of calves according to Fokkink et al. (2010).

Alfalfa hay was provided to calves after 35 days of age *ad libitum*. Quality of hay was medium, 1 kg had 848 g DM,

Table 2
Composition of pelleted protein concentrate (pPC)

Ingredients	$g.kg^{-1}$
Soybean meal	325
Sunflower meal	200
DDGS from maize	200
Wheat, grounded	200
Limestone	20
Molasses	50
Premix♦	5
Total	1000

♦ 1 kg premix contains: 6 000 000 IU vitamin A, 800 000 IU vitamin D_3, 25 000 mg vitamin E, 60 000 mg manganese, 12 000 mg copper, 60 000 mg zinc, 240 mg cobalt, 780 mg iodine, 240 mg selenium

Table 1
Quantity of colostrum (HQCol = high quality colostrum, Col = colostrum) and milk, and frequency of offering liquid feed (x) to calves

Group	Age of calves, days					Total liquid feed, L
	1	2	3–35	36–49	50–56	
LM	HQCol-6 L,3x	Col-6 L,3x	Milk-4 L,2x	Milk-2 L,1x		172
MM	HQCol-6 L,3x	Col-6 L,3x	Milk-6 L,2x	Milk-6 L,2x	Milk-3 L,1x	315
HM	HQCol-6 L,3x	Col-6 L,3x	Milk-8 L,2x	Milk-8 L,2x	Milk-4 L,1x	416

0.61 FUG, 153 g CP or in 1 kg DM 0.72 FUG and 180 g CP. Clean water was offered in bucket from the 4th day of age, and was changed with fresh water every morning. Composition and energy value of different feeds are presented in Table 3.

Table 3

Chemical composition and energy value of feeds

Items	pPC*	Maize	Starter feed	Alfalfa hay
Dry mater, g/kg	854	868	861	848
In 1 kg DM, g				
FUG**	1.38	1.77	1.58	0.72
Crude protein	339.58	102.19	220.89	180.0
Crude fiber	92.39	26.50	59.44	307.8
Ether extracts	30.91	44.93	37.92	25.94
Calcium	11.51	0.29	5.90	14.15
Phosphorus	7.51	3.18	5.34	2.41

* pPC – Pelleted protein concentrate
** FUG – Feed units for growth, according to Todorov et al. (2007)

Amounts of milk, starter feed and alfalfa hay offered and refused were recorded daily. Feed units for growth (FUG, equivalent to 6 MJ net energy for growth) according to the Bulgarian energy evaluation system were estimated in daily calf rations using published data (Todorov et al., 2007). Total feed and milk DM, and FUG per 1 kg live weight gain were calculated for different experimental periods and groups. Live weight (LW) of calves and size growths (withers height and heart girth) were measured at birth, 35, 56 and 70 days of age.

Fecal output was scored daily throughout the trial for consistency (1 = normal, firm, 2 = soft, spreads easily, 3 = very soft or runny, 4 = watery, liquid consistency and mucus or trace of blood), and odor (1 = normal, 2 = slightly offensive, 3 = offensive, and 4 = highly offensive). The beginning of rumination, non-feeding oral behavior and vocalizing (bellowing) was observed for 2 hours each day 4 h after the morning milk feeding from 15 to 35 days of age. Duration of rumination was recorded by three people (one for each group) on 5 calves per group in 4 consecutive days for 6 h from 6:00 – 12:00, 12:00 – 18:00, 18:00 – 24:00 and 24:00 – 6:00 h during 53 – 56, and 67 – 70 days of age. Incidence and duration of health disorders and administration of antibiotics and electrolytes or other treatments were recorded during experiment.

Dry mater, crude protein, crude fiber, ether extract, calcium and phosphorus in feeds are determined according methods described by AOAC international (2007). Average value of immunoglobulin in colostrum (estimated by measuring blood serum protein on second day of age with clinical refractometer (Pennsylvania, USA) and using correlation with Ig) for 4 groups of calves varied from 12.8 to 14.6 mg/ml. Therefore, calves received enough Ig with colostrum.

Data were analyzed for statistical significance of differences using the mixed procedure of SAS (2003).

Results and Discussions

Starter and hay intake. Dry feed consumption started between 6 and 11 days of age of calves. There were high variations in acceptance and intake of starter in early life of calves. Differences between groups in days of age for beginning eating starter feed were not significant (P > 0.05). Big variations in starting dry feed consumption were reported also by Kertz and Chester-Jones (2004). Khan et al. (2008) found that calves start consuming solid feed at about 14 days of age, or one week later than in this trial.

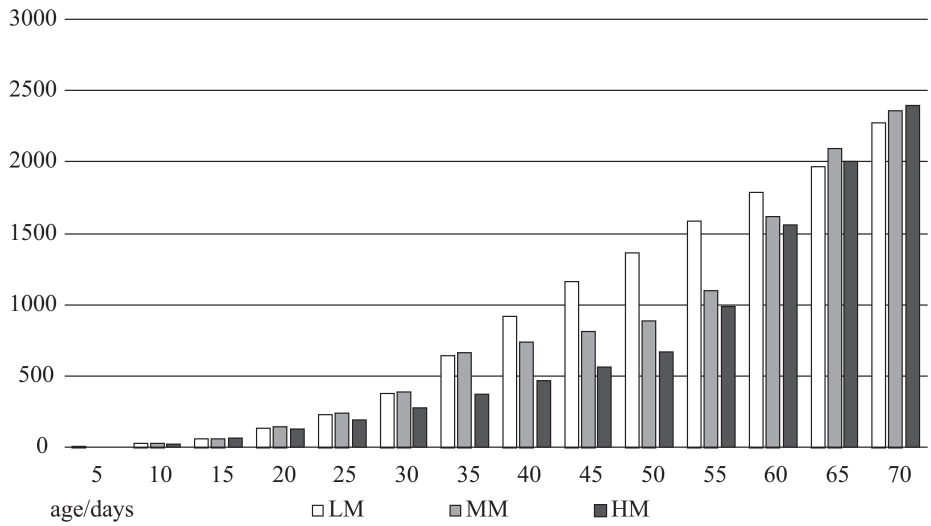

Fig. 1. Starter intake changes with age of calves, g/day

Intake of dry feed was very low for first month of life of calves or for the first 20–25 days after the first attempt to eat starter feed. Unexpectedly there were no significant differences in starter intake until 35 days of age between the LM and MM groups of calves. However, calves receiving 8 L of milk daily tend to consume less dry feed. Once a day feeding with ½ of milk quantity stimulated dry feed intake, and consumption increased rapidly for the three groups of calves. A substantial increase of starter intake was observed after complete weaning of calves (Figure 1 and Table 4). A similar response of calves was reported by Jasper and Weary (2002).

Total DM and net energy (FUG) consumption during the first 35 days of age was different between groups ($P < 0.05$), which allowed significant differences in LWG ($P < 0.005$). For the next period (from 36 to 56 days of age) the consumption of DM was almost equal for the three groups, but FUG intake was higher for groups receiving more milk. Differences in FUG intake between groups were smaller, and were significant between LM compared with MM and HM groups. In the post-weaning period there were no differences in starter and hay intake by three groups of calves (Table 4). Total dry matter and net energy (FUG) intake were practically equal too.

There were inverse relationships between milk intake and dry feed intake, which was obvious between 35 and 55 days of age (Figure 1). Data for total DM intake between 35 and 56 days of age are almost equal for the three groups of calves. There was an almost complete replacement of starter feed and hay DM by milk DM.

Significant differences in solid feed consumption were previously reported when calves were offered restricted or *ad libitum* amounts of liquid feed (Jasper and Weary, 2002; Khan et al., 2007a, b). Reduction of calf starter intake in higher level of milk replacer feeding was reported also by Raeth-Knight et al. (2009), Cobb and Ballon (2010), Hengst et al. (2010) and Paula et al. (2012**)**. However when differences in milk consumption were small (4.5 vs. 5.4 L/day) Carlson et al. (2011) did not found significant difference in starter intake. Khan et al. (2011) and Paula et al. (2012) reported no significant differences in starter intake amount in calves fed different quantity of milk. Increased starter consumption compensating for lower milk intake and growth in LW was similar for calves receiving different level of milk in the experiment of Carlson et al. (2009).

After 35 days of age alfalfa hay was offered, but consumption did not differ ($P > 0.05$) depending on the level of milk fed (Table 4). Khan et al. (2010) reported that calves with free access to hay consumed less starter after weaning, but more total DM (starter plus hay) and had higher average weight gain than calves without access to hay. Rumen and reticulum weights with and without digesta were heavier in calves fed hay.

Table 4

Intake of feed, total dry matter (DM) and feed units for growth (FUG) of calves during different age in days (d)

Items	Low milk (LM)	Moderate milk (MM)	High milk (HM)
Beginning to eat starter, d	6a	8a	11a
Starter DM intake, kg			
Birth to 35 d	7.59a	7.69a	5.23a
36 to 56 d	26.69a	18.75b	14.39b
57 to 70 d	28.7a	29.36a	28.74a
Birth to 70 d	62.98a	55.8ab	48.36b
Hay DM intake, kg			
36 to 56 d	3.2a	2.5a	2.5a
57 to 70 d	3.5a	3.4a	3.6a
36 to 70 d	6.7a	5.9a	6.1a
Total DM intake, kg*			
Birth to 35 d	26.20a	34.52b	40.28c
36 to 56 d	33.38a	34.33a	34.33a
57 to 70 d	32.2a	32.76a	32.34a
Birth to 70 d	91.78a	101.61b	106.95c
Total FUG intake**			
Birth to 35 d	55.29a	74.58b	89.82c
36 to 56 d	52.66a	61.87b	65.13b
57 to 70 d	47.87a	48.74a	48.0a
Birth to 70 d	155.82a	185.19b	202.95c

ab – Data without same letter are significant at $P < 0.05$
* Sum of colostrum (18.0% DM), milk, starter feed and hay
** Feed units for growth (FUG) according to data of Todorov et al. (2007) 1 FUG is equal to 6 MJ net energy for growth

Growth of calves

Allowing more whole milk to dairy calves increased body weight of calves and average daily gain during the pre-weaning period. The calves of HM group doubled their body weight by weaning at 56 days of age. Therefore, calves reach the requirement for accelerated rate of gain within the first two months, which results in more milk production in first lactation and subsequent lactations of their life (Moallem et al., 2010; Soberon and van Amburgh, 2013). Differences in early life milk consumption and growth rate did not influence later dry feed intake and live weight gain of calves (Tables 4 and 5). Thus, greater body weight for calves fed previously more milk (HM group) was maintained in the post-weaning period. Similar results were obtained by Miller-Cushon et al. (2011).

Increasing level of milk feeding was reported to increase the growth rate of calves by Terre et al. (2009), Hill et al. (2010), Uys et al. (2011), Ozkaya and Toker (2012) and Daniels et al. (2013). Meta-analysis of Bateman II et al. (2010) showed that increasing starter or milk intake increased LWG

Table 5
Live weight (LW), live weight gain and feed efficiency at different age in days (d)

Items	Low milk (LM)	Moderate milk (MM)	High milk (HM)
Live weight, kg			
at birth	38.5a	38.2a	38.4a
on 35 d	52.0a	58.0ab	63.1b
on 56 d	66.3a	73.3ab	79.0b
on 70 d	79.4a	86.3ab	91.6b
LW gain, kg			
Birth to 35 d	13.5a	19.8b	24.7c
36 to 56 d	14.3a	15.3a	15.9d
57 to 70 d	13.1a	13.0a	12.6a
Birth to 70 d	40.9a	48.1b	53.2b
LW gain, g/day			
Birth to 35 d	386a	566b	706c
36 to 56 d	681a	729a	757a
57 to 70 d	936a	929a	900a
Birth to 70 d	584.a	687b	760b
DM*/LW gain			
Birth to 35 d	1.94a	1.74ab	1.63b
36 to 56 d	2.33a	2.24a	2.16a
57 to 70 d	2.46a	2.52a	2.57a
Birth to 70 d	2.25a	2.11a	2.01a
FUG**/LW gain			
Birth to 35 d	4.09a	3.77a	3.64a
36 to 56 d	3.68a	4.04a	4.10a
57 to 70 d	3.65a	3.75a	3.81a
Birth to 70 d	3.81a	3.85a	3.81a

ab – Data without same letter are significant at $P < 0.05$
* DM = dry mater from milk, starter and hay
**Feed units for growth

of calves. However, Paula et al. (2012a) did not found significant differences in body gain when calves received 4, 6 or 7.3 L milk replacer, probably because increasing starter intake by calves receiving less milk replacer.

Increased intake of energy in calves before 2 months of age showed no negative effects on subsequent milk production (Brown et al., 2005). Furthermore, some fat deposition during the preweaning period can probably play a beneficial role to combat milk weaning stress in calves.

Same evidence exist that during weaning and transition to only dry feed calves receiving 8 L of milk per day experienced some growth check (tendency for lower daily gain during 57 to 70 days of age), compared to calves receiving less milk. At the same time there was a tendency for decreasing feed efficiency in groups with higher level of milk intake. Observed tendency for low average daily gain after 56 days of age in HM group evidently was not connected with low total dry matter intake or net energy intake (Table 4). Therefore, there was a tendency for changing feed: LWG ratio. This could be a result of lower digestibility of dry feeds in calves receiving more milk preweaning.

Significant check of LWG after weaning of calves fed *ad libitum* with milk was reported by Miller-Cushon et al. (2011). Hill et al. (2014a) reported reduction of LWG after weaning of calves fed high level of milk replacer, compare to those fed low level. However, Stayer et al. (2014) do not found weaning slump of calves fed accelerated milk replacer program compare to moderate level of feeding. Big variations in different experiments about the impact of level of milk feeding on post weaning growth of calves probably depend on the level and quality of dry feed consumption during this period and method of ceasing milk feeding.

Feed utilization

There were significantly less DM expenses per 1 kg LWG in HM group, compared to LM group ($P < 0.05$) before 35 days of age. However, proportion of milk, which had higher digestibility and net DM energy value, was much bigger in HM group, compared to LM group. There were no significant ($P > 0.05$) differences between the three experimental groups in DM and net energy FUG) efficiency after 35 days of age (Table 5). FUG efficiency tended to increase with increasing level of milk feeding until 35 days of calf's age. Later the tendency was the opposite, decreased efficiency with increasing of milk feeding level. It seems that the balance between growth rate effect and maintenance requirement effect caused the differences in two tendencies. Evidently calves with higher daily gain have also higher maintenance needs and this compensate expected better efficiency when LWG was higher.

Depression in post-weaning digestion in calves fed high level of liquid feed was reported by Hill et al. (2009), Xu et al. (2011) and Hill et al. (2014). The authors related the depression in digestibility to reduce starter intake and delayed rumen development.

There were equivocal results of experiments for rumen development in calves receiving different level of milk or milk replacer. Hammon et al. (2014) reported that intensive (8 L per day) milk replacer feeding did not impair concentrate intake and slightly affected rumen papillae growth, compared to calves fed 6 L milk replacer daily. Todd et al. (2009) reported that calves receiving 5 L milk replacer started consumption of starter earlier and had greater starter intake, increased rumen wall thickness, longer and wider papillae and reduced papillae density ($P < 0.05$), than more abundantly fed calves. However, the level of milk replacer feeding did not influence rumen papillae area and sub-mucosal thickness, independently of better growth of calves receiving more milk replacer in trial of Davidson et al. (2013).

Another explanation of the tendency for higher total DM intake to LWG ratio could be deposition of more fat into the body of calf fed more milk preweaning (MM and HM groups). This assumption was supported by the higher net energy (FUG) to LW gain ratio in HM group, compared to LM group (P = 0.08) during 36 – 56 days of age.

Therefore, there is some tendency for slump of growth and feed efficiency after weaning of calves receiving 8 L milk per day, which this experiment cannot explain satisfactorily. There are no data for similar check in calves receiving 4 or 6 L milk daily. May be a longer transition period from milk to dry feeds will allow a complete avoiding of slump in growth of abundantly fed with milk calves.

Size of calves

Size of calves receiving more milk tended to be higher, compared to calves fed low level of milk, but differences were not significant before 56 days of age (P > 0.05). Differences were significant (P < 0.05) only between LM and HM groups after 56 days of age for withers height, and at 70 days of age for heart girth of calves. Some advantages of HM group during the preweaning period remained during next 14 days (Table 6). Feeding different quantity of milk, affected the size of body almost in the same way, as live weight and gain of calves were influenced.

Table 6
Withers height and heart girth in calves (n = 20) at different days (d) of age

Items	Low milk (LM)	Moderate milk (MM)	High milk (HM)
Withers height, cm			
at birth	77.3a	77.0a	77.2a
on 35 d	82.9a	83.5a	84.5a
on 56 d	87.1a	88.1ab	89.9b
on 70 d	88.9a	90ab	91.8b
Heart girth, cm			
at birth	83.3a	83.1a	83.4a
on 35 d	91.0a	90.9a	92.0a
on 56 d	95.0a	97.8a	98.5a
on 70 d	97.9a	101.0ab	102.2b

ab – Data without same letter are significant at P < 0.05

Health status

There were no differences in diarrhea, pneumonia and other illness among three groups receiving different quantity of milk.

Rumination

Rumination started after 15 days of age in some calves. The average age of beginning rumination was between 19 and 25 days for different groups (Table 7). Duration of rumination increased from 121 – 152 min. at 53 – 56 days of age to 208 – 215 min at 67 – 70 days of age. Time for rumination and number of rumination bouts per day decreased with increasing level of milk feeding per day, and the difference was significant only between LM and HM groups in 53 – 56 days of age (P < 0.05). Reduced time of rumination evidently was connected with lower dry fed consumption of calves fed more milk. Big individual variations were observed between the calves even in one group. Rumen development and rumination time have been apparently affected due to decreased starter intake of calves fed 8 L milk per day. However after weaning there was no difference in starter intake and in rumination. This means that any hold up in rumen development is small and tentative.

There was tendency for firmer feces and fewer sums of scouring days in calves receiving more milk per day (Table 7). Some researchers reported a higher occurrence of diarrhea in calves supplied higher levels of milk or milk replacers, compared with restricted fed calves (Diaz et al., 2001; Quigley et al., 2006), but others reported no difference (Jasper and Weary, 2002; Khan et al., 2007a). A high incidence of diarrhea is rather related to poor sanitary, management, and housing conditions than to level of milk intake (Hammon et al., 2002; Jasper and Weary, 2002).

In all three experimental groups, without engorgement of bit, a significant non-feeding oral behavior (oral movement

Table 7
Rumination at different age (d = days) and fecal scores

Items	Low milk (LM)	Moderate milk (MM)	High milk (HM)
Beginning of rumination, d	19a	22a	25a
Rumination, min./24h			
On 53 – 56 d	152 a	140ab	121b
On 67 – 70 d	215a	208a	213a
Ruminating bouts/day			
On 53 – 56 d	15.7a	13.8ab	11.0b
On 67 – 70 d	22.0a	23.1a	21.6a
Average fecal score			
Consistency	1.5a	1.3a	1.2a
Odor	1.2a	1.3a	1.3a
Fecal scores ≥ 3, sum for group, days			
Consistency, d	12a	13a	10a
Odor, d	8a	10a	6a

ab – Data without same letter are significant at P < 0.05

like chewing, movement of tongue and licking own mouth) was observed. This oral behavior was more pronounced in LM group, compared to other groups of calves. There were no significant differences in behavior of calves receiving different quantity of milk. There was a tendency for more vocalization of calves from LM group first days after weaning, compare to vocalization after weaning of calves from other groups. The differences were probably connected with age of weaning. Behavior of calves showed a tendency for improved welfare of calves receiving more milk.

Except for DM intake, net energy (FUG) intake and LWG from birth to 35 days of age, there were no significant differences in controlled indices after 35 days of age between calves fed 6 and 8 L milk up to 49 days of age. It seems that advantages of feeding HM level (8 L milk/day) finished at 35 days of age of calves. Therefore it is doubtful whether it is justified to feed 8 L of milk afterwards, e. g. after rumen development and quick increasing of dry feed intake.

After decreasing the quantity of milk and complete weaning at 49 (LM) or 56 (MM, HM) days of age, no measured parameter in this trial (growth, feed efficiency, health or behavior) was affected by level of milk feeding to heifer calves.

Cost of diets for the 70-day experimental period and per 1 kg LWG were calculated according to current prices during the period of trial (Table 8). Price was 150 Euros per ton of maize, and 286 Euros per ton of pelleted protein concentrate. For unmarketed milk 85% of price of regular milk, which is 353 Euro per ton, was taken.

Table 8

Cost of diet for 70 days of trial and for 1 kg LWG, in Euro

Feeds	€/ton feed	Low milk (LM)	Moderate milk (MM)	High milk (HM)
Cost of feeding 1 calf				
Srarter feed	218	17.54	14.13	12.25
Alfala hay	92	0.73	0.64	0.66
Milk	300	51.60	94.50	124.80
Total per calf		69.87	109.27	137.71
Percents (LM = 100)		100	156	197
Cost of 1 kg LWG		1.71	2.27	2.59
Percents (LM = 100)		100	133	151

Conclusions

High level of milk feeding enhanced live weight and body frame size growth rate of calves, and improved feed efficiency, but evidently 8 L milk per calf per day increased stress of transition from liquid to dry feed at weaning. It seems that increasing the transition to dry feed to two weeks will avoid any slump in growth. Level of milk feeding did not affect health status of calves pre- and post-weaning. The growth and development of caves after weaning did not depend on the level of milk feeding before weaning. Reduction of quantity of milk fed to calves was partially compensated by increased dry feed intake and the growth was not a direct response to milk intake. There was a tendency for better utilization of energy (FUG) with increasing level of milk feeding until 35 days of age, but the differences were not significant. However, there was a tendency for increasing ratio of net energy (FUG) intake to live weight gain after 35 days of age, which could be connected with decreased digestibility of dry feed or deposition of more fat into the body of calves fed more milk (MM and HM groups). There were significant variations in the age at starting rumination and in dry feed consumption among calves.

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Received June, 2, 2014; accepted for printing December, 2, 2014.