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The effect of free or restricted acidified milk feeding of Finnish Ayrshire bull calves on the subsequent fattening and slaughter performance

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The aim of the research was to study whether the anticipated added weight gain from ad libitum acidified milk feeding compared to restricted milk feeding during the preweaning period can be maintained after weaning until slaughter. The study was conducted by comparing first the growth performance of eleven bull calves until an average age of 126 days (Phase 1) when the five calves were fed acidified milk either ad libitum (FM) for 17 weeks or when six calves were given acidified milk restrictively (5 l per day, RM) for nine weeks. Bulls had ad libitum access to grass silage and concentrate. Secondly, the performance of bulls having an average age of 175 days until slaughter (at an average age of 429 days) at a carcass weight of approximately 290 kg was assessed (Phase 2). All animals were fed grass silage ad libitum and concentrate at a level of 620 g kg^{-1} of dietary dry matter.

Calves fed acidified milk ad libitum grew significantly ($P < 0.01$) faster than those fed restrictively during the first nine weeks of Phase 1 (1003 vs. 725 g per day). The bulls in the RM group grew a little but not significantly faster during Phase 2, the growth rates being 1197 vs. 1207 g per day. The feed conversion, weight (535 vs. 533 kg at slaughter) and slaughter results were equal. Similarly the life-time gains did not differ being 1174 (FM) and 1141 (RM) g per day, respectively. It can be concluded that the improved performance during early life did not improve growth during the fattening period.

Key words: calves, bulls, milk feeding, growth, feed intake, performance

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Introduction

Free access to whole milk would be the most natural feeding system for both dairy and beef calves. This would, however, also be the most expensive feeding method for preweaned dairy or crossbred calves and therefore feeding based on the restricted use of either milk replacer or whole milk is generally applied to these calves. However, calves can consume high levels of milk e.g. when milk not valid for human consumption is available, when beef or crossbred calves are suckling dams with a high milk yield or when dairy calves are reared under organic regulations (CEC 1999).

Increasing intake levels of milk or milk replacers has improved the live weight gain of preweaned calves (Woodford et al. 1987, Miller et al. 1999, Jasper and Weary 2002). The growth performance over the whole growth period including both pre- and postweaning is critical from the economic viewpoint as it affects the length of the feeding period needed to attain the target slaughter weight. The amount of milk fed strongly affects the production costs during the preweaning period, since the price of milk is high compared to other feeds and thus it is important to assess how long the growth advantage will be maintained after weaning.

Could free access to acidified milk during the calf stage due to anticipated improved performance be an alternative or even superior feeding strategy for dairy breed bull calves through adding extra weight until slaughter and improving life-time performance? Does nutritional history affect e.g. the carcass fat grade is also an important question. There is little data comparing the performance of dairy breed animals from birth to slaughter when milk was given freely or in restricted amounts during the preweaning period. The aim of this experiment was 1) to measure how the anticipated increased weaning weight of bulls fed acidified milk ad libitum is maintained after weaning, 2) to compare feed conversion efficiency and 3) slaughter data of animals with different nutritional history. The study consisted of two phases, the calf-stage (Phase 1) when dairy breed bull calves were fed acidified milk either ad libitum or restrictively, and the fattening stage until slaughter (Phase 2) when the bulls were fed the same diet.

Material and methods

The study which started in May 1993 was carried out indoors in the experimental barn of MTT Agrifood Research Finland in Jokioinen, Finland. Twelve bull calves of the Finnish Ayrshire breed were taken into the experiment at an average age of 7 days and having an average live weight of 41.7 kg (±4.3 kg). One animal on free milk (FM) treatment died due to a reason unrelated to the study so that results of eleven animals were used. All eleven animals remained generally healthy throughout the study. During their first week of life the calves were given whole milk 2 litres twice a day, totalling 10% of body weight. Animals were housed in individual pens during the calf stage which lasted for 17 weeks until an average age of 126 days (Phase 1). Calves were randomly allotted to the two experimental treatments. In the free milk feeding, the five calves had free access to nipple feeding of acidified [3 l of Freeze-dried REDI-SET (Dairy culture: Mesophilic Aromatic Culture Type: LD, CH-N 11) / 40 l of milk] milk (ambient temperature about 20°C) during the entire Phase 1. In the restricted milk feeding (RM), the six calves were given 2.5 litres of milking-warm acidified milk twice a day (at 0700 and 1600) during the first nine weeks and were weaned thereafter. All the calves had free access to water, concentrate and grass silage during the entire Phase 1. Grass silage was direct-cut from a timothy (*Phleum pratense*) and meadow fescue (*Festuca pratensis*) sward and ensiled in bunker silos with a formic acid-based additive applied at a rate of 5 l t^{-1}. The concentrate consisted of barley and a commercial mineral mixture (Seleeni-Minera, 50 g kg^{-1} dry matter (DM)) during the first nine weeks and thereafter (weeks 10–

17) a mixture of barley (667 g kg^{-1} DM), rapeseed meal (267 g kg^{-1} DM; Raisio Nutrition Ltd., PO Box 101, FIN-21201 Raisio) and a commercial mineral mixture (66 g kg^{-1} DM; Seleeni-Minera). During the Phase 1 there was some occasional incidences of diarrhea but in general real health problems were not observed because milk was acidified.

After Phase 1 there was a period of an average of 49 days before the beginning of Phase 2 due to technical reasons. The animals were housed indoors in a tie stall barn and they had free access to water, concentrate (the same as in Phase 1 during weeks 10–17) and grass silage. In addition, the calves in the FM group consumed a small amount of milk. The average feed intakes were 0.44 kg DM of milk, 1.46 kg DM of concentrate and 1.92 kg DM of silage in the FM group and 1.91 kg DM of concentrate and 3.24 kg DM of silage in the RM group.

The fattening period (Phase 2) started at an average age of 175 days and lasted until slaughter. The animals were housed indoors in a tie stall barn. The bulls were planned to be slaughtered individually when they reached the target live weight of 550 kg and then the average age of animals was 429 days. Grass silage was given ad libitum. The targeted consumption of concentrate was 670 g kg^{-1} of the daily total ad libitum DM intake estimated at the beginning of each four-week period. The concentrate (Raisio Nutrition Ltd., PO Box 101, FIN-21201 Raisio) consisted of (g kg^{-1} DM) barley (300), molassed sugar beet pulp (180), wheat bran (90), wheat feed flour (90), rapeseed meal (260), molasses (60) and vegetable oil mixture (20).

Feed intake was recorded individually every day in both phases. The calves were weighed weekly in Phase 1. The growing animals were weighed on two consecutive days at the start of Phase 2, every 28 days thereafter and on two consecutive days at the end of Phase 2. Milk samples were taken twice a month and analysed for DM, fat, protein and lactose. The milk composition was analysed using a Milko-Scan 605 analyser (Foss Electric, Hillerød, Denmark). Concentrate and silage samples for chemical analyses were taken at every feeding and pooled for periods of four weeks for concentrate and for periods of two weeks for grass silage. Feed samples were analysed as described by Aronen et al. (1992). At the end of the study, all animals were slaughtered and the carcass weight, dressing % and carcass muscle and fat score were measured.

The live weight gains for Phase 1 and 2 were calculated for each animal by difference (end weight – starting weight). The experimental design was a randomised block design having milk feeding strategy as a class variable. The average feed DM intake, growth rate and slaughter data (least squares means) were subjected to analysis of variance using the SAS general linear models (GLM) procedure (Littell et al. 1991).

Results

The average chemical composition of the experimental feeds is presented in Table 1. Both the nutritional and ensiling quality of the grass silages was good in both phases.

The average feed intake in Phase 1 is shown in Table 2. The milk intake of the FM calves was much higher and their concentrate intake lower ($P < 0.05$) compared to the RM calves. The total DM intake of the FM calves tended ($P = 0.08$) to be higher compared to those on RM group during weeks 1–9 resulting in a 1.4 times higher ($P < 0.001$) intake of metabolizable energy (ME).

During weeks 10–17, the calves consumed 4.3 times more concentrates ($P < 0.001$) and 7.1 times more silage ($P < 0.001$) in the RM group compared to the calves still having free access to milk. The concentrate intake of the calves in the RM group reached 1.7 kg DM during week 11 and did not increase much thereafter but silage intake continued to increase until the end of Phase 1 (Fig. 1). The calves in the FM group doubled their concentrate intake during the last weeks. Because the calves in the FM group consumed a great amount of milk (1.51 kg DM), their total DM intake during weeks 10–17 was

Table 1. Chemical composition of the experimental concentrates and the grass silages.

	Phase 1			Phase 2	
	Concentrate Weeks 1–9	Concentrate Weeks 10–17	Grass silage	Concentrate	Grass silage
Dry matter (DM) (g/kg)	890	883	303	881	248
Organic matter (OM) (g/kg DM)	935	915	932	946	919
Crude protein (g/kg DM)	125	189	165	199	131
Neutral detergent fibre (g/kg DM)	–	–	496	–	555
In vitro[1)] OM digestibility (g/kg OM)	–	–	798	–	707
Metabolizable energy (MJ/kg DM)	12.7	12.0	11.8	11.9	10.4
Absorbed amino acids (g/kg DM)	100	109	88	113	78
Fermentation quality of silage					
pH		–	3.87	–	4.14
Acetic acid (g/kg DM)		–	27	–	17
Lactic acid (g/kg DM)		–	68	–	36
Water soluble carbohydrates (g/kg DM)		–	16	–	32
In total N (g/kg N)					
NH_4N		–	32	–	32
Soluble N		–	662	–	482

[1)] determined using cellulase method.

Table 2. Feed intake in Phase 1.

	FM	RM	SEM	P-value
Dry matter intake (kg/day)				
Milk				
Weeks 1–9	1.09	0.59	–	–
Weeks 10–17	1.51	0.0	–	–
Weeks 1–17	1.29	0.33	–	–
Concentrate				
Weeks 1–9	0.12	0.32	0.058	< 0.05
Weeks 10–17	0.39	1.68	0.033	< 0.001
Weeks 1–17	0.27	0.95	0.045	< 0.001
Silage				
Weeks 10–17	0.28	1.98	0.165	< 0.001
Weeks 1–17	0.15	1.00	0.092	< 0.001
Total				
Weeks 1–9	1.24	1.06	0.069	ns
Weeks 10–17	2.18	3.68	0.177	< 0.001
Weeks 1–17	1.71	2.28	0.111	< 0.01
Metabolizable energy intake (MJ/day)				
Weeks 1–9	24.6	17.8	1.05	< 0.001
Weeks 10–17	40.5	44.4	2.30	ns
Weeks 1–17	32.0	30.2	1.51	ns

FM = free milk feeding during Phase 1; RM = 5 l milk per day during the 9 first weeks of Phase 1.
SEM = standard error of the mean. Means presented are least squares means.
ns = $P \geq 0.05$.

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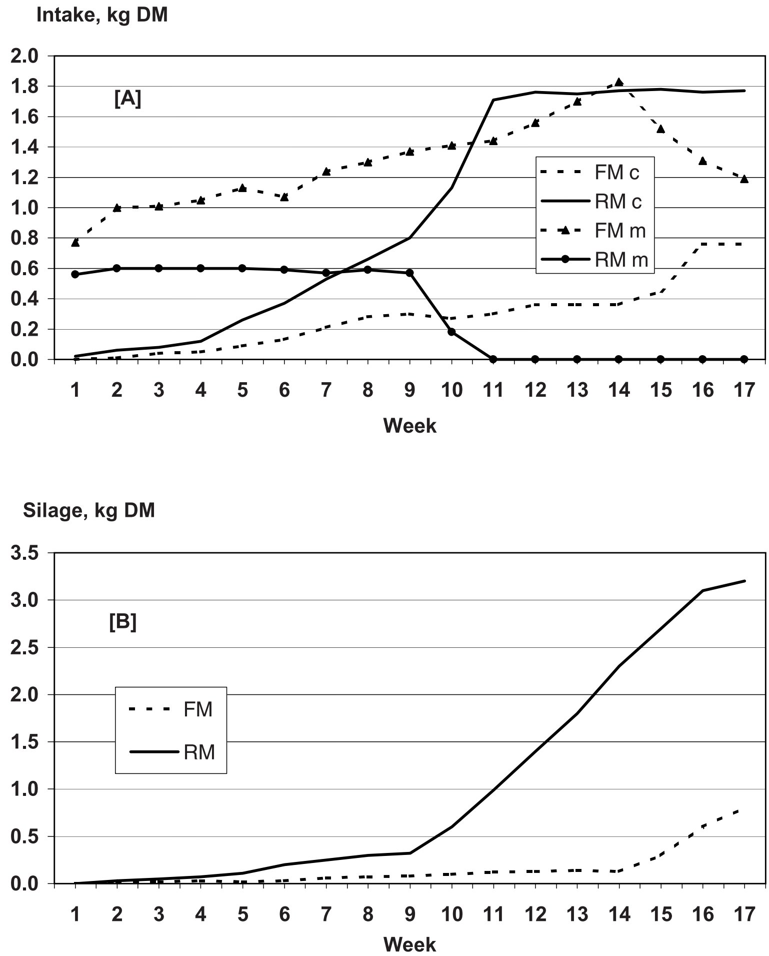

Fig. 1. Daily intake (kg DM) of concentrate and milk [A] and silage [B] of calves given either free milk (FM) or restricted milk (RM) feeding in Phase 1. c = concentrate, m = milk.

only 60% of that of the calves in the RM group ($P < 0.001$), showing a 1.98 substitution rate of concentrate plus silage intake to kg milk DM.

Animal performance during Phase 1 is shown in Figure 2 and in Table 3. The weights were greater for the calves in the FM group compared to the RM calves during the whole Phase 1 (Fig. 2.). The live weight of the calves in the FM group was 19% higher ($P < 0.01$) than those in the RM group at the end of week 9, but at the end of week 17 the difference was reduced to 7%. The daily gain of the calves in the FM group was higher (1003 vs. 725 g; $P < 0.01$) during weeks 1–9. The energy conversion was similar

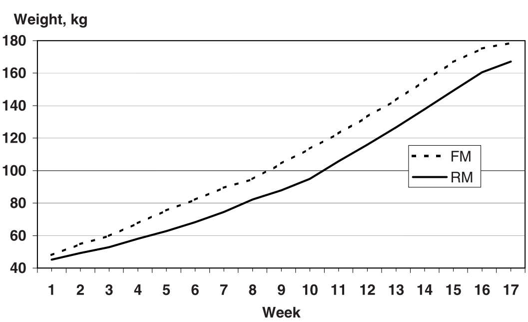

Fig. 2. Live weight of calves given either free milk (FM) or restricted milk (RM) feeding in Phase 1.

Table 3. Animal performance during Phase 1.

	FM	RM	SEM	P-value
Live weight (kg)				
Initial	41.2	42.2	2.02	ns
At the end of week 9	104.4	87.8	3.56	< 0.01
At the end of week 17	178.6	167.2	6.54	ns
Daily gain (g/day)				
Weeks 1–9	1003	725	50.4	< 0.01
Weeks 10–17	1361	1447	65.5	ns
Weeks 1–17	1168	1061	53.2	ns
Energy conversion				
Metabolizable energy (MJ/kg weight gain)				
Weeks 1–9	24.6	24.7	0.70	ns
Weeks 10–17	29.9	30.6	0.85	ns
Weeks 1–17	27.5	28.4	0.44	ns

FM = free milk feeding during Phase 1.
RM = 5 l milk per day during the 9 first weeks of Phase 1.
SEM = standard error of the mean. Means presented are least squares means.
ns = $P \geq 0.05$.

between the groups. The daily gains between Phase 1 and 2 were 1227 g for the FM group and 1107 g for the RM group (not shown in Table).

The average feed intake and animal performance during Phase 2 are presented in Table 4. The average feed and nutrient intakes were similar between the groups. The average proportion of concentrate consumed was 620 g kg^{-1} DM in both groups. This was slightly lower than the targeted 670 g kg^{-1} DM. Figure 3 illustrates how the live weights of the bulls in the RM group reached the live weights of the bulls in the FM group at the end of Period 7. During Phase 2, the average total gain, feed and energy conversions and slaughter data were similar for both groups. The mean gains during the whole life time were 1174 g for the FM group and 1141 g for the RM group (not shown in Table 4).

Discussion

During Phase 1 the calves in the FM group were heavier than those in the RM group. The average daily gains of the RM calves were moderate (72% of the daily gain of the FM calves) during weeks 1–9. This difference reflected the lower average total ME intake of the RM calves due to the restricted milk supply (54% of ad libitum consumption). In addition, the high content of absorbed amino acids in milk also explained the difference. Jasper and Weary (2002) reported 0.48 vs. 0.78 kg daily gain for female Holstein calves fed milk restrictively (10% of body weight) or ad libitum for 36 days. Holstein bulls grew similarly faster (0.71 vs. 0.30 kg) when given ad libitum acidified milk replacer vs. regular (sweet) milk replacer at a rate of 10% of body weight (Woodford et al. 1987). These experiments clearly show the beneficial effect of free milk supply allowing high intake levels of nutrients of calves to support fast growth in the early stage of life.

Although free milk intake by suckling beef calves is a common practice in beef breed production systems, the real level of milk yield of beef cows is not well defined (Miller et al. 1999). In a beef production system after a 187-day preweaning period, calves of beef cows having a greater genetic potential for milk production

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Table 4. Average feed intake and animal performance in Phase 2.

	FM	RM	SEM	P-value
Dry matter intake (kg/day)				
Concentrate	4.82	4.91	–	ns
Silage	2.77	2.81	0.073	ns
Total	7.59	7.72	0.204	ns
Metabolizable energy (ME) intake (MJ/day)	85.8	87.4	2.38	ns
Initial weight (kg)	237	223	11.0	ns
Final weight (kg)	535	533	10.4	ns
Gain (g/day)	1197	1207	58.4	ns
Energy conversion (MJ ME/kg weight gain)	72.2	73.2	3.67	ns
Slaughter data				
Days until slaughter	251	260	11.4	ns
Age at slaughter (days)	423	434	7.4	ns
Carcass weight (kg)	292.1	291.1	8.2	ns
Dressing %	54.6	54.6	0.73	ns
Carcass muscle score[1)]	10.2	10.0	0.47	ns
Carcass fat score[2)]	2.40	2.00	0.157	ns

[1)] values were either 9 or 11, 11 more muscular than 9.
[2)] values were either 2 or 3, 3 fatter than 2.
FM = free milk feeding during Phase 1; RM = 5 l milk per day during the 9 first weeks of Phase 1.
SEM = standard error of the mean. Means presented are least squares means.
ns = $P \geq 0.05$.

were heavier compared to calves of dams having a lower genetic potential for milk production (Lewis et al. 1990). Miller et al. (1999) also reported that increased milk yield of beef cows was associated with increased preweaning gain and biological efficiency of growth of the calves.

During the last eight weeks of Phase 1, the FM animals consumed little concentrate and a negligible amount of silage due to the high average milk intake. This demonstrated a high substitution rate (1.98) of concentrate plus silage DM intake to kg milk DM. During that time calves in the RM group who had been weaned increased greatly their intake of both concentrate and silage. This increased the energy intake of the RM calves and allowed doubling their average daily gain. There were, however, no differences in growth rate and energy conversion, because average ME intakes were similar in both groups. It should be pointed out that the average

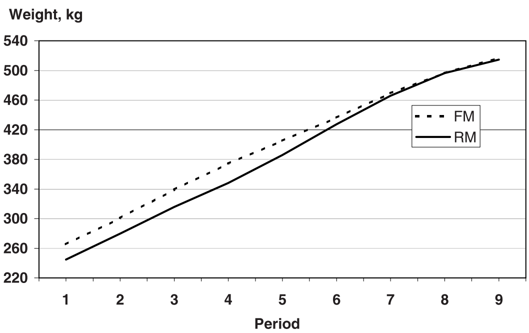

Fig. 3. Live weight of calves given either free milk (FM) or restricted milk (RM) feeding in Phase 2. Length of period is four weeks.

daily gain of both groups during weeks 10–17 was 1404 g, which is a good growth for dairy breed calves and maybe close to their potential.

In the study by Jasper and Weary (2002) there were no significant differences in average daily gains (0.68 ad libitum vs. 0.85 kg conventional milk feeding 10% of body weight) and average intakes of barley-based starter (1.85 vs. 1.89 kg, respectively) after weaning from day 43 to 63. Their study showed that a high milk consumption before weaning did not decrease the starter intake after weaning.

The average daily gains were quite similar during the seven-week period between Phase 1 and 2. The bulls in the FM group were 11.4 kg and 14.0 kg heavier at the end of Phase 1 and at the beginning of Phase 2, respectively. This showed that this period did not change the circumstances before Phase 2, since the difference was still present at the beginning of Phase 2.

In the intensive feeding system prevailing during Phase 2, the bulls in the FM group were not able to maintain greater gains and did not show improved energy conversion. Thus these animals did not show superior growth compared to the other group, and at slaughter time the final weights and carcass quality were similar between the FM and the RM group. Also similar life-time growths (1174 vs. 1141 g per day) demonstrated that high consumption of milk in early life cannot be recommended as a superior rearing strategy of dairy breed bulls compared to the commonly used restricted milk feeding.

Miller et al. (1999) did not observe any effect of the milk yield of the dam (weaning age of 200 days) on the biological efficiency of growth of calves in the feedlot until slaughter, but they reported larger carcasses. Calves suckled by dams in the high-milk group maintained, during 280 days in the feedlot growth period to slaughter, 63% of their weaning-weight advantage (age 205 days) over those in the low milk group (Clutter and Nielsen 1987). These studies were conducted using beef breed animals with considerably longer milk feeding periods, and therefore these results may not be directly comparable to the present situation.

In conclusion, in Phase 1 calves having access to free milk supply consumed a high total amount (154 kg DM) of milk but grew faster than restrictively fed calves only during the first nine weeks. After that restrictively fed bulls were able to catch up the difference in daily gain by a slightly faster (non-significant difference) live weight gain, demonstrating that the restriction of early growth did not depress subsequent growth. In this study, the final growth and slaughter results were equal for both groups, revealing that the slight restriction of growth during the preweaning period had no negative carry-over effects on the later performance of the animals. The results showed that the nutritionally most suitable but also very expensive ad libitum milk feeding of dairy calves during the preweaning period did not exhibit superior subsequent performance during the fattening period. Thus the final performance of dairy bull calves raised for beef production was not dependent on the milk feeding strategy implemented during the calf stage.

References

Aronen, I., Toivonen, V., Ketoja, E. & Öfversten, J. 1992. Beef production as influenced by stage of maturity of grass silage and level of supplementary concentrates. *Agricultural Science in Finland* 1: 441–459.

Clutter, A.C. & Nielsen, M.K. 1987. Effect of level of beef cow milk production on pre- and postweaning calf growth. *Journal of Animal Science* 64: 1313–1322.

CEC 1999. Council regulation No 1804/1999 supplementing regulation No 2092/91 on organic production. *Official Journal of the European Communities* L222: 1–28.

Jasper, J. & Weary, D.M. 2002. Effects of ad libitum milk intake on dairy calves. *Journal of Dairy Science* 85: 3054–3058.

Lewis, J.M., Klopfenstein, T.J., Stock, R.A. & Nielsen, M.K. 1990. Evaluation of intensive vs. extensive systems of beef production and the effect of level of beef cow milk production on postweaning performance. *Journal of Animal Science* 68: 2517–2524.

Littell, R.C., Freund, R.J. & Spector, P.C. 1991. *SAS® system for linear models*. Cary NC, USA. SAS Institute Inc. 329 p.

Miller, S.P., Wilton, J.W. & Pfeiffer, W.C. 1999. Effects of milk yield on biological efficiency and profit of beef production from birth to slaughter. *Journal of Animal Science* 77: 344–352.

Woodford, S.T., Whetstone, H.D., Murphy, M.R. & Davis, C.L. 1987. Abomasal pH, nutrient digestibility, and growth of Holstein bull calves fed acidified milk replacer. *Journal of Dairy Science* 70: 888–891.

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SELOSTUS

Vapaan ja rajoitetun maitojuoton vaikutukset ayrshiresonnien kasvuun koko kasvatuskauden aikana ja teurastuloksiin

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Tässä tutkimuksessa selvitettiin, vaikuttaako vasikkakauden vapaa maitojuotto maitorotuisten lihanautojen kasvuun ja teurastuloksiin. Kokeessa oli yhteensä 11 vasikkaa, jotka jaettiin kahteen ryhmään. Toinen ryhmä sai koko vasikkakauden ajan eli 17 viikkoa vapaasti hapatettua maitoa. Toinen ryhmä sai kahdesti päivässä 2,5 litraa hapatettua maitoa 9 viikon ajan, jonka jälkeen ne vieroitettiin. Molemmat ryhmät saivat vasikkakaudella vapaasti väki- ja säilörehua.

Vasikkakauden jälkeen molemmat ryhmät ruokittiin samalla lailla. Väkirehun osuus rehuannoksen kuiva-aineesta oli 620 g/kg ja säilörehua annettiin vapaasti. Sonnit teurastettiin keskimäärin 429 pv ikäisinä, jolloin niiden ruhot olivat keskimäärin 292 kg painoisia.

Vapaasti maitoa saaneet vasikat joivat ensimmäisten 9 viikon ajan enemmän maitoa kuin rajoitetusti juotetut (1.09 vs. 0.59 kg kuiva-aineena) ja ne kasvoivat nopeammin (1003 vs. 725 g/pv). Vasikkakauden loppupuoliskolla molemmat ryhmät kasvoivat yhtä nopeasti (vapaasti juotetut 1361 g/pv ja rajoitetusti juotetut 1447 g/pv).

Kasvatuskauden alkaessa keskimäärin 175 pv iässä vapaasti juotetut sonnit olivat keskimäärin 14 kg painavampia (ei merkitsevä ero) kuin rajoitetusti juotetut sonnit. Kasvatuskauden aikana ryhmien välillä ei ollut merkitseviä eroja päiväkasvussa, rehun muuntosuhteessa, kasvatusajan pituudessa eikä teurastuloksissa. Tulokset osoittavat, että runsaan maidonjuonnin aiheuttama kasvun nopeutuminen vasikkakaudella ei vaikuttanut myönteisesti lihanautojen kasvuun koko kasvatuskautta tarkasteltaessa.