294 Impact of free-choice or restricted water intake during the pre-weaning and early post-weaning period on calf performance and health. A. Manthey*[1], D. Ziegler[2], H. Chester-Jones[2], M. Raeth-Knight[3], G. Golombeski[3], and J. Linn[3], *[1]University of Wisconsin-River Falls, River Falls, [2]University of Minnesota, Southern Research and Outreach Center, Waseca, [3]University of Minnesota, St. Paul.*

Two studies were conducted to compare the impact of free choice versus restricted water intake during the milk replacer (MR) feeding period and 2 wk following weaning on calf performance. Study 1 was conducted spring of 2009 and study 2, summer of 2010. A total of 114 (study 1 = 44; study 2 = 70) 2 to 4 d old Holstein calves were assigned to 1 of 2 treatments: 1) Free choice water intake for 56 d (CON) or 2) Restricted water intake (RW). The RW treatment was no water available the first 36 d of the study followed by limited amount offered (2.3 kg/d) d 36 to 42 and free choice d 42 to 56. All calves were fed 0.28 kg of a 20:20 MR powder in 2 kg water twice daily d 1 to 35 and once daily d 36 until weaning at 42 d. Medicated MR was utilized in study 1 and non-medicated MR in study 2. An 18% CP calf starter (CS) was offered free choice d 1 to 56. Water, MR and CS intakes along with fecal scores were recorded daily. Body weight (BW) was measured d 1, 14, 28, 42 and 56 and hip height d 1 and 56. Data were analyzed as repeated measures using the PROC MIXED procedures of SAS. Study was included in the model as a blocking factor and initial BW was used as a covariate. During the MR feeding period (d 1–42), CON calves in study 1 and 2 consumed more water ($P < 0.05$) per d than the RW calves (study 1 = 0.54 vs. 0.22 kg/d; study 2 = 1.9 vs. 0.34 kg/d). Due to differences in season between studies, CON calves in study 2 consumed 1.4 kg more water per d than CON calves in study 1 from d 1 to 42 ($P < 0.05$). Average daily water intake from d 1 to 56 was similar for calves on the CON and RW treatment in study 1 averaging 1.6 kg water/d, but in study 2, CON calves consumed 1.0 kg more water per d ($P < 0.05$) compared with RW calves (2.9 vs. 1.9 kg/d). In both studies, differences in water intake between CON and RW treatments did not affect daily gain, CS or total DM intake from d 1 to 42 or d 1 to 56. Across studies, overall CS intake, total DM intake and daily gain averaged 0.66, 0.91, and 0.55 kg/d, respectively. Under conditions of these studies restricting water intake in the first 42 d did not affect calf performance.

Key words: dairy calves, water intake

295 Effects of free-access feeding of acidified milk replacer on the performance and general health of veal calves. C. G. Todd*[1], T. J. DeVries[2], K. E. Leslie[1], J. M. Sargeant[1], N. G. Anderson[3], K. Shore[4], and S. T. Millman[5], *[1]Department of Population Medicine, University of Guelph, Guelph, ON, Canada, [2]Department of Animal Poultry Science, University of Guelph, Kemptville Campus, Kemptville, ON, Canada, [3]Ontario Ministry of Agriculture, Food and Rural Affairs, Elora, ON, Canada, [4]Grober Nutrition, Cambridge, ON, Canada, [5]Veterinary Diagnostic and Production Animal Medicine, Iowa State University, Ames.*

The aim of this research was to examine the effects of milk replacer acidification for free-access feeding on the performance, morbidity and mortality of veal calves. Holstein male calves were randomly assigned at birth to free-access feeding of A) milk replacer (22% CP, 17% fat; n = 32) or B) acidified milk replacer (n = 31). Acidified milk replacer was prepared using formic acid (target pH: 4.0 to 4.5). Calves were weaned off milk replacer at 42 d of age. Milk replacer, starter ration and water intakes were measured daily from birth until weaning. Preweaning BW gain was determined weekly. After weaning, calves were transitioned to a growing/finishing diet for grain-fed veal, weighed every 2 weeks and slaughtered at 6 mo of age. At slaughter, the lungs of each calf were collected and evaluated for gross pathological changes. Dressed carcass weights were obtained. Multivariable regression models were constructed to examine the effects of treatment on milk replacer intake, time to onset of starter consumption, BW gain and carcass weight. Differences between treatment groups for disease events and death were tested using Pearson's $\times^2$ or Fisher's exact. Calves assigned to the acidified treatment consumed less milk replacer (10.1 vs. 11.3 L/d, SE = 0.2, $P < 0.01$) and began consuming starter ration earlier (32.0 vs. 39.5 d, $P < 0.05$) than the control calves. Milk replacer acidification tended to be associated with reduced preweaning ADG (0.9 vs. 1.0 kg/d, SE = 0.1, $P < 0.1$), but did not affect BW at weaning (85.1 vs. 87.8 kg, SE = 2.0, $P > 0.05$), postweaning ADG (1.2 vs. 1.2 kg/d, SE = 0.01, $P > 0.05$) or carcass weight (150.2 vs. 149.2 kg, SE = 3.3, $P > 0.05$). Calves did not differ for diarrhea occurrence (A vs. B: 36.1 vs. 42.6%, $P > 0.05$) or death (A vs. B: 3.2 vs. 1.6%, $P > 0.05$). There was, however, a tendency for fewer acidified-fed calves to have lung tissue affected with lesions of pneumonia (6.9 vs. 19.0%, $P < 0.10$). These results indicate that under free-access feeding conditions, acidification limits the intake of milk replacer, but does not negatively affect long-term calf performance, and may support improved respiratory health.

Key words: acidified, calf, milk replacer

296 Effect of Celmanax SCP on calf performance when fed in the milk replacer and grower phase. R. J. Dennis[1] and S. Jalukar*[2], *[1]Kent Nutrition Group Product Development Center, Muscatine, IA, [2]Varied Industries Corporation, Mason City, IA.*

Effect of supplementing Celmanax SCP, an ultra-concentrated product consisting of yeast culture and hydrolyzed yeast cell wall, in milk replacer and starter feed on dairy calves was evaluated. Fifty, day-old calves were allotted based on body weight to following 2 treatment a) calf milk replacer (MR) (20%CP:20% fat; non-medicated fed 568g daily) for 6 wk and control starter and grower diet from wk 7–20 and b) MR + 1g/h/d of Celmanax SCP for 6 wk and starter and grower diet + 2 g/h/d Celmanax SCP from wk 7–20. Calves were housed individually through d42 and in super hutches with 5–6 calves/hutch and bunk fed starter (18%CP) till d56. In grower phase (d57–84) calves were penned in 2 groups (control and SCP) and fed a 14% grower diet via self feeders. Serum protein analysis and vaccination to BVD was done for each calf. Along with the MR, control calves were treated upon arrival with Sulfamethoxazole-trimethoprim antibiotic tablets for the first 3 d and Celmanax SCP calves were fed 3g/h/d SCP for the first 2 d. Thereafter, Celmanax SCP was fed at 1g/h/d to the treatment group. Weight gain, milk replacer and starter intake, and feed efficiency of the calves were recorded. Data were analyzed by ANOVA for a completely randomized design using Statistix 8 analytical software. MR intake was similar for both treatments but there was a trend for starter intake to be higher with Celmanax SCP treatment. Starter intake was 29.12 kg and 57.24 kg after 6 and 8 wk for Celmanax SCP verses 25.58 kg and 53.48 kg after 6 and 8 wk for the control calves ($P \geq 0.18$). Average weights at the start and end of the trial were 37.43 kg and 186 kg for the calves receiving Celmanax SCP verses 36.86 kg and 181.99 kg for control treatment respectively. Throughout the experiment, calves

on Celmanax SCP showed numerically higher weight gains and they were 2.4 kg and 4.0 kg heavier at the end of 8 wk and 20 wk ($P \geq 0.2$) compared with control. The feed efficiency (F/G) was also numerically lower compared with control ($P \geq 0.2$). In conclusion, calves supplemented with Celmanax SCP showed numerical improvement in starter intake, weight gain, and feed efficiency.

Key words: calves, yeast, milk replacer

297 Effect of different forage sources on performance and feeding behavior of Holstein calves. L. l. Castells*[1], A. Bach[1,2], G. Araujo[1], and M. Terré[1], *[1]Department of Ruminant Production, IRTA, Caldes de Montbui, Spain, [2]ICREA, Barcelona, Spain.*

One hundred and 70 9 Holstein male calves participated in a series of 3 studies to evaluate the effect of different forage sources on performance and feeding behavior. Each study was conducted involving 60 calves (initial BW 45.0 ± 5.33 kg and 14.1 ± 4.17 d of age). Animals were randomly assigned to one of 3 different dietary treatments: control (CTR) calves were fed concentrate without any forage provision (this treatment was repeated in each of the 3 studies), and the 2 other treatments consisted on the same concentrate plus a forage source depending on the study: chopped alfalfa (AH) or rye-grass hay (RH); chopped oats hay (OH) or chopped barley straw (BS); corn silage (CS) or triticale silage (TS). All calves were offered 2 L of milk replacer (MR) at 12.5% DM twice daily via a bottle until 50 d of age, and 2 L of MR at 12.5% DM during the week before weaning (57 d of age). Starter, MR, and forage intakes were recorded daily and BW was recorded weekly. Calves were individually housed and bedded with wood shavings. Performance data were analyzed with an ANOVA with repeated measures, and behavior data were analyzed with a Poisson regression analysis. Compared with CTR, animals receiving OH, TS and BS consumed more ($P < 0.01$) starter (880 vs. 1140, 1170, 1060 ± 28 g/d, respectively) and grew faster ($P < 0.01$; 722 vs. 926, 880, 876 ± 38.3 g/d, respectively). On average, animals in treatments RH, BS, CS, and TS consumed 51 g/d of DM of forage, that was less ($P < 0.01$) than that obtained with AH (120 ± 19.8 g/d) and OH (101 ± 19.8 g/d). Compared to CTR calves, animals in AH and RH treatments spent more ($P < 0.01$) time ruminating (odds ratio vs CTR: 5.24 and 5.40, respectively), calves AH, RH devoted less ($P < 0.01$) time to perform non-nutritive oral behavior (odds ratio vs CTR: 0.38, 0.34, respectively), and TS calves tended ($P = 0.06$) to devote less time to perform non-nutritive oral behavior (odds ratio vs CTR: 0.21). In conclusion, free-choice provision of a forage source to young calves improves feed intake, performance, and, depending on forage source, reduces non-nutritive oral behaviors and stimulates rumination.

Key words: forage, calves, performance

298 Effect of fatty acid intake by dairy calves on performance, health, and markers of immunity. T. M. Hill*[1], M. J. VandeHaar[2], L. M. Sordillo[2], H. G. Bateman II[1], and R. L. Schlotterbeck[1], *[1]Nurture Research Center, Provimi North America, Lewisburg, OH, [2]Department of Animal Science, Michigan State University, East Lansing, [3]Department of Large Animal Clinical Sciences, Michigan State University, East Lansing.*

The aim of the present study was to determine the effect of supplementing milk replacer (MR) with 1% NeoTec4, a commercially available blend of butyric, coconut, and flax oil, on calf growth, feed efficiency, and indices of immune function when the calves were fed 28% CP MR at a high rate of intake (powder fed at 2% of BW). In the Trial 1a, 48 calves were fed either a MR which contained only animal fat (control) or the same MR with NeoTec4 (treatment). In Trial 1b, weaned calves from Trial 1a, were fed dry feed for 28 d without NeoTec4, then half the calves fed NeoTec4 for 28 d. Data were analyzed as a completely randomized design with repeated measures using PROC MIXED and NPAR1WAY. In Trial 1a, NeoTec4 improved ADG, feed intake, feed efficiency, reduced the number days with scours, and tended ($P = 0.06$) to reduce treatments for Clostridium. In addition, NeoTec4 lessened the inflammatory response to vaccination with Pasteurella at 5-wk-old, as observed by reduced hyperthermia and hypophagia and alleviation of the TNF-α response. In addition, NeoTec4 tended ($P = 0.09$) to increase the post-Pasteurella challenge response in IL-4 in mononuclear cells, increased serum globulin protein. Post-booster vaccination titers for BVD and PI3 were increased in calves fed NeoTec4. In Trial 1b, there were no differences in performance during the first 28 d when no calves received NeoTec4, but calves receiving NeoTec4 in the second 28 d had greater ADG and feed efficiency. We conclude that supplementation of MR with NeoTec4, a blend of butyrate, coconut and flax oils, improves some immune responses, which may partly explain the reduction in scours and concurrent improvements in growth rate and feed efficiency.

Key words: dairy calves, immunity, fatty acids

299 Impact of feeding various fats and fatty acids on dairy calf performance, health, and markers of immunity. T. M. Hill*, H. G. Bateman II, J. M. Aldrich, and R. L. Schlotterbeck, *Nurture Research Center, Provimi North America, Lewisburg, OH.*

We evaluated the impact of feeding various fats and fatty acids on castrated Holstein calf performance in 3 56-d trials. PROC MIXED and NPAR1WAY were used and $P < 0.05$ was considered significant in all trials. In Trial 1, 48 3-d old calves were fed a milk replacer with 2 fat types (all animal or a blend of animal, coconut, and soy fats) and with or without 1.25% of a blend of butyrate, medium chain fatty acids, and linolenic acid (NeoTec4, Provimi North America, Lewisburg, OH) in a completely randomized design in a 2 × 2 factorial arrangement with repeated measures. Fat type did not affect performance. Calf ADG, starter intake, feed efficiency, hip width change, and post-booster serum titers to BVD and PI3 vaccines were greater in calves fed NeoTec4. The rectal temperature increase to a Pasteurella vaccine was greater in calves fed the fat blend vs. all animal fat. Post-vaccination rectal temperatures increase was less in calves fed MR with NeoTec4 vs. without NeoTec4. In Trial 2, 48 3-d old calves were fed starters with A) 0.5% NeoTec4, 0% soy oil, B) 0.5% NeoTec4, 2.0% soy oil, and C) 0% NeoTec4, 0% soy oil in a completely randomized design with repeated measures. Calves fed starter A had greater ADG than calves fed starter B or C. Calves fed starter A had greater hip width change than calves fed starter C. In Trial 3, 96 8-wk old calves were fed 4 growers: A) control, B) 0.25% Flaxtech (Virtus Nutrition, Corcoran, CA), C) 0.5% NeoTec4, and D) 1.5% soy oil as a randomized complete block design. There were 2 blocks based on 2 groups of calves starting the trial at different times. Calf ADG was greatest in calves fed NeoTec4 and least in calves fed soy oil. Hip width change was greater in calves fed NeoTec4 than in calves fed the control or soy oil diet. In summary, addition of soy oil to starter and grower feeds reduced ADG while adding NeoTec4 fatty acids to milk replacers, starter and grower feeds increased ADG and hip width change.

Key words: dairy calves, immunity, fatty acids

300 Impact of three times versus twice a day milk replacer feeding on calf performance, likelihood to reach lactation and future milk production in a commercial dairy herd. D. C. Sockett*[1], C. E. Sorenson[2], N. K. Betzold[3], J. T. Meronek[3], and T. J. Earleywine[4], *[1]Wisconsin Veterinary Diagnostic Laboratory, University of Wisconsin, Madison, [2]United Cooperative, Sauk City, WI, USA, [3]University of Wisconsin-Madison, College of Agricultural & Life Sciences, Madison, [4]Land O'Lakes Inc., Cottage Grove, WI.*

Seventy, Holstein heifer calves were enrolled in a trial designed to evaluate both the short and long-term effects of feeding a full potential milk replacer (MR) diet (28% protein, 20% fat) either 3 times or twice a day. Within 6 h of birth, calves were fed a commercial colostrum replacement product made from bovine colostrum that contained 150g of IgG. Calves were randomly assigned to either 3 times or twice a day feeding. A blood sample was collected from each calf 1–3 d after birth. Serum was tested for bovine IgG by single radial immunodiffusion. Calves were housed outdoors in individual calf hutches until they were weaned and moved to group pens at 50–55 d of age. All the calves were fed at 08:00 and 21:00 h. Calves fed 3 times a day received an additional meal at 14:30 h. Calves were fed 815g of MR/day from d 1–7, 1135g of MR/day from d 8–42 divided into either 3 or 2 feedings. Both groups of calves were fed 565g of MR once a day (pre-weaning process) from d 43–49. Calf starter (20% CP as fed) was offered to the calves beginning at 3–4 d of age. Calf starter intake was measured daily. Calves were weighed and had their hip height measured weekly. All the calves remained in the herd unless they died or were culled. Each animal's calving date was recorded and milk production assessed using mature-equivalent 305-d (ME305) milk yield estimated at ≥120 d in milk. Data (birth weight, serum IgG, hip height and weight gain, feed efficiency, calf starter intake, age at first calving and ME305) was evaluated using ANOVA and co-variance using a G.L.M. procedure (NCSS-2007, Kaysville, Utah). The likelihood of calves being weaned, entering lactation and calculation of relative risk was analyzed using 2-way contingency table analysis (JavaStat). Calves fed 3 times a day had improved growth (hip height and weight gain), better feed efficiency, consumed more calf starter during the pre-weaning process and were more likely to enter lactation (relative risk 1.21, 95% C.I. 1.02–1.45) than calves fed twice a day.

Table 1. Results

Item	2x Feeding	3x Feeding	*P*-value
Number calves	35	35	1.0000
Birth weight, kg	40.1	39.8	0.7385
Serum IgG mg/mL	11.2	12.2	0.3459
Calf starter intake, DM (1-42 days), kg	3.3	3.9	0.3448
Calf starter intake, DM (43-49 days), kg	3.8	4.8	0.0122
BW gain (1-42 days), kg	25.1	29.8	0.0001
Hip height gain (1-42 days), cm	8.6	10.3	0.0027
Feed efficiency (gain/DM intake, 1-42 days)	0.52	0.61	0.0001
Number weaned	32	34	0.3070
Number lactating	28	34	0.0250
Age first calving, days	734	718	0.2278
ME305, milk production, kg	13053	13568	0.2265

Key words: feeding, growth, lactation

301 Effects of a modified intensive milk replacer program fed two or four times daily on nursery calf performance. A. D. Kmicikewycz*, D. N. da Silva, and N. B. Litherland, *University of Minnesota, St. Paul.*

The objective of this study was to determine if milk replacer (MR) program and feeding frequency (2 vs. 4 meals/day) altered calf performance. Forty-eight Holstein and cross-bred heifer and bull calves were assigned according to body weight (BW), breed, sex, and total protein to 4 treatments (T) (n = 12): T1) 20% CP:20% fat MR fed at 1.5% BW 2 × daily (d); T2) 20:20 MR fed at 1.5% BW 4 × d; T3) 26:18 MR fed at 2.0% BW 2 × d; or T4) 26:18 MR fed at 2.0% BW 4 × d. All calves were fed at 0600 and 1700 h and T2 and T4 were fed additionally at 1100 and 1400 h. Treatments were fed from 1 to 42 d and all MR feeding rates were adjusted weekly to maintain 1.5% or 2.0% of BW reconstituted at 15% DM. Calves were weaned on d 42 by reducing the MR feeding frequency by 50% on d 36. Calves were housed in hutches bedded with straw and offered water and a texturized 18% CP starter ad libitum. Calf growth was measured weekly and starter intake and fecal scores recorded daily. Data were analyzed using Proc Mixed in SAS as a completely randomized design with repeated measures and the least significant difference test was used for mean separations when main effects were significant ($P < 0.05$). Birth BW averaged 41.8 kg. Average daily gain (ADG) d 1–42 was similar ($P = 0.39$) and averaged 0.59, 0.63, 0.69, and 0.71 kg/day for T1, T2, T3 and T4 (SEM = 0.05). ADG from d 1–56 was also similar among treatments ($P = 0.18$) and averaged 0.62, 0.72, 0.78 and 0.75 kg/d for T1, T2, T3, and T4 (SEM = 0.06). Starter intake averaged 0.88 for T1, 1.12 for T2, 0.81 for T3, and 0.75 for T4 (kg/day). T2 had the greatest starter intake on wk 6 and 7 ($P < 0.05$; T × wk). BW was greater for T3 vs. T1 on wk 8 ($P < 0.05$; T × wk). BW gain from d 1 to 42 were similar ($P = 0.4$) and averaged 24.9 and 26.4 kg for T1 and T2, while T3 and T4 calves gained 28.8 and 29.8 kg. BW gain from d 1 to 56 was not different ($P = 0.2$) and averaged 34.9, 40.1, 43.9, and 42.2 kg for T1, T2, T3 and T4. Fecal scores did not differ. Feeding a 20:20 MR 4 times daily resulted in greater starter intake yielding 5.2 kg additional gain through d 56.

Key words: calf, milk replacer, feeding frequency

302 Effect of different levels of alfalfa hay and sodium-propionate supplementation on performance and rumen development of dairy calves. H. Beiranvand, M. Khorvash, G. R. Ghorbani*, A. Riasi, S. Kargar, and M. Mirzaei, *Isfahan University of Technology, Isfahan, Iran.*

Forty 2 male Holstein calves (46 ± 3.0 kg) were used to evaluate the effect of alfalfa hay (as physical factor) inclusion at different levels and sodium-propionate (as chemical factor) supplementation on performance and rumen development. The experiment was conducted as complete randomized design with a 2 × 3 factorial arrangement. Treatments consisted of 1) concentrate only (Control); 2) concentrate plus 5% sodium-propionate (Control + Pro); 3) concentrate + 5% forage only (5% F); 4) 5% forage + 5% sodium-propionate (5%F+ Pro) = ; 5) concentrate + 10% forage only (10% F); and 6) 10% forage + 5% sodium-propionate (10% F+ Pro). All data were analyzed using the MIXED procedure of SAS (SAS, 2003). All dietary treatments were provided ad-libitum in addition to milk (4 kg/head/day). Concentrate was provided as meal form and alfalfa hay was chopped with geometric mean particle size of 2.6 mm. Nine calves from selected treatments (Control, 10% F, and 10% F + Pro; 3 calves per treatment) were euthanized at 70 d of age. Alfalfa hay supplementation increased dry matter intake and average daily gain but propionate effect or propionate ×

forage interaction were not influenced significantly. Adding alfalfa hay reduced feed efficiency ($P < 0.02$). Compared with calves on propionate those fed forage had lower weaning days (61 vs. 45 d). Rumen wall in calves fed forage showed thinner keratin layer and had stronger muscles layer compared with control. Results indicated that adding forage in the form of chopped alfalfa hay positively influenced growth performance and microscopic appearance of the rumen epithelium and rumen wall as well as decrease in weaning ages.

Key words: alfalfa hay, propionate, rumen development

303 Effect of pre-weaning feeding regimens on post-weaning growth performance of Sahiwal calves. S. A. Bhatti*[1], A. Ali[1], D. McGill[2], M. Sarwar[1], H. Nawaz[1], M. Afzal[3], M. S. Khan[1], M. A. Amer[4], R. D. Bush[5], P. C. Wynn[2], H. M. Warriach[2], and H. Nawaz[1], *[1]Institute of Animal Nutrition and Feed Technology, University of Agriculture, Faisalabad, Pakistan, [2]E H Graham Centre (NSW Industry and Investment and Charles Sturt University), Wagga Wagga, Australia, [3]Pakistan Agricultural Research Council, Islamabad, Pakistan, [4]Livestock Production Research Institute, Bahadurnagar, Okara, Pakistan, [5]Faculty of Veterinary Science, University of Sydney, Camden, Australia.*

The objective of the study was to establish the post-weaning growth potential of Sahiwal calves reared on 4 different pre-weaning diets. Sahiwal calves (n = 48; 24 of each sex 3 ± 2 d of age) were divided into 4 groups of 12 animals each (6 of each sex) and were offered one of the following dietary treatments from d 3 ± 2 postpartum: A: whole cow′s milk + starter ration (SR; CP = 20%, TDN = 72%) plus Berseem clover hay (H; *Trifolium alexandrinum*; CP = 21% TDN = 63%); B: Milk + H; C: Milk replacer (MR; reconstituted to specification; Sprayfo) + SR+H and D: MR + H. Milk or MR was offered at the rate of 10% of their body weight until d 56 and then withdrawn gradually until weaned completely by d 84. The SR and H were continued until d 84. During the post-weaning period the calves were fed a single total mixed ration containing 16% CP and 70% TDN, from the 13th to the 24th week of age. This ration was fed ad libitum, daily feed intake was measured and live-weights were recorded weekly. The data were analyzed by MIXED procedures of SAS. The initial live-weight, growth rate, total live-weight gain and final live-weight of calves at 24 weeks of age were 56 ± 1, 47 ± 1, 40 ± 1 and 30 ± 1 kg; 746 ± 33, 660 ± 34, 654 ± 33 and 527 ± 33 g/d; 63.2 ± 2.6, 55.2 ± 2.7, 54.9 ± 2.7 and 44.2 ± 2.6 kg; and 119 ± 4.2, 102 ± 4.3, 95 ± 4.3 and 75 ± 4.2 kg for the pre-weaning treatments A, B, C and D, respectively; these were influenced ($P < 0.05$) by the pre-weaning treatments. Offering whole milk from birth at the rate of at least 10% of bodyweight with concentrates leads to a higher weaning weight and post-weaning growth rate and hence a greater possibility of early maturity.

Key words: calf nutrition, post-weaning growth