Influence of teat flow rate in commercial milk feeding systems on calf digestion and performance

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ABSTRACT

Seventy two, one day old Friesian heifer calves were fed whole milk either via medium or slow release teats on commercial calfeteria systems (Milkbar, McInnes Manufacturing Limited, Waipu, New Zealand) for 42 days. For the entire period, the consumption time for the calves fed on the medium flow rate teat calfeterias was twice as fast as for those fed on the slow teat calfeterias. Meal intake was numerically higher for the calves fed using the slow teats. At day 42, calves on the slow teats had a strong trend towards higher daily gain. At 14 days of age, visual differences in curding were seen in the abomasum of culled calves, with the fast teat-fed animals having large lumps of curded milk surrounded by watery liquid, whereas the slow teat-fed calves had much smaller particle sized curding in thicker fluid. Lactose digestion in the stomach was significantly higher for the calves fed using the slow flow rate teats, and there was a strong trend for higher levels of free protein in the ileum. Using slow flow rate teats to feed calves from day old to weaning appears to have an important impact on digestive processes in the immature gut. Such improvements in digestion and rumen development in young calves may assist in the digestion of milk and other feeds, leading to improved growth performance. Under farm conditions, slow release teat system may reduce scours and other digestive problems in young calves during peak milk intake (up to 15 d of age), due to increased ileal digestion of nutrients, preventing undigested nutrient flow to the hind gut.

Keywords: calf, teat flow rate, digestion, feed intake, rumen development

Introduction

The rate of milk feeding in calves fed from calfeterias may vary due to several factors, including the size of the calf at birth, the speed of learning to drink from teats, the ability to compete within a group and flow rate of milk from the rubber teats used. If left on the dam to be reared naturally, calves are more regulated in milk intake, as the cow will govern their consumption times, and milk is available throughout the day (Albright and Arave, 1997). In commercial rearing situations, calves are fed twice or once a day (Ternouth and Roy, 1973; Jasper and Weary, 2002) depending on age, and typically have to compete with others in their group for adequate intake (Jensen, 2003), especially when they are group housed in large pens and sheds, as is common practice in New Zealand rearing operations. In certain farming situations, due to lack of labour or time constraints, farmers prefer fast flow teats as this cuts down on the time needed to feed calves around other daily chores on the farm, some even slitting the teat end to speed up flow deliberately.

Clotting of milk in the immature, simple stomach (abomasum) of calves is an important first step in digestion (Frantzen *et al.*, 1973; Strudsholm, 1988; Longenbach and Heinrichs, 1998) although there is a dearth of information on how rate of milk consumption affects this important parameter. Additionally there is no information available specifically on how teat flow speed affects milk clotting, despite the fact that various teats are used widely in calf production today. Fast milk consumption can lead to problems in calves, including overfilling the immature stomach (Radostits and Bell, 1970; Blowey, 2008), leading to a flow of undigested milk into the intestines, where it can be utilised by pathogenic bacteria acquired from the environment further down the tract (Porter, 1969; Blowey, 2008). This can result in digestive disorders,

scouring and potential higher mortality, especially where calves are kept in environments with high bacterial loads and/or poor farm biosecurity (Wise and Lemaster, 1968; Longenbach, 1998; Blowey, 2008). In addition, certain behavioural issues can be seen in calves which consume milk at faster speeds (Haley *et al.*, 1998; Margerison *et al.*, 2003; Herskin *et al*, 2010). It appears that calves fed via fast flow systems, can become satiated more quickly, and therefore may not consume their daily allowance adequately, due to the large quantity of milk entering the immature stomach (Appleby *et al.*, 2001; Jasper and Weary, 2002). This has been associated with an increase of navel, tail and udder sucking (dePassillé, 2001; Jung and Lidfors, 2001; Jensen, 2003, Jensen and Budde, 2006). Sucking the immature udder can lead to premature removal of the keratin plug, which protects the individual teats from infection, especially in heifers coming into first milk, as well as navel and skin infections. Both Haley *et al.*, 1998 and Herskin *et al*, 2010 compared the behaviour of calves fed either via different diameter tubes from buckets or large or small teat apertures, leading to slow or fast drinking patterns in calves. In both cases, these authors reported that the slower fed calves had less incidence of non-nutritive (cross) sucking of body parts of other calves.

The aim of the current trial was to determine if medium and slow calfeteria teats give true differences in milk intake times, calf growth and digestive characteristics under controlled conditions.

Materials and methods

Seventy-two, one day old Friesian heifer calves were used in the experiment. Calves were fed whole milk via either the control teats (medium release) or the treatment teats (slow release), which are regulated via a mesh insert and aperture size, on commercial calfeteria systems (Milkbar, McInnes Manufacturing Limited, Waipu, New Zealand).

Twelve calves were randomly and individually housed in cubicles (1 m x 1.6 m) and fed using single teat calfeterias with either medium or slow teats (n=6). The remaining calves were randomly assigned to groups in six large (4 x 4 m) pens on deep litter wood shaving bedding, to give a minimum of 1.6 m^2 per calf (to adhere to New Zealand welfare legal rearing space limits of 1.5 m^2 per calf).

Calves were collected from pasture after 12 hours on the dam following birth, and transferred to the trial site. For four days they received 2 litres of colostrum twice a day. From five to eleven days of age, calves were fed 2.75 litres of half colostrum and half milk twice a day. From day 12 of age, calves were fed 5.5. litres of milk once a day (in morning), to allow an intake of 500 g of milk solids per calf per day at 9% dry matter content of whole milk (as per prior milk analysis). This is equivalent to recommended dry matter milk solids intakes for commercial milk replacers.

Three individually housed calves from each treatment were humanely culled at either seven or fourteen days of age and dissected in order to take samples from the abomasum for assessing curding (by photograph and sampling), upper ileum and rectum as well as being retained for digestibility. Animals were culled two hours after feeding to allow coagulation and flow of digesta into the ileum for sampling purposes (Smith and Sissons, 1975). Samples of colostrum and milk were retained for analysis of lactose and protein. At the end of the 42 day rearing period, all group housed heifer calves were returned to the farmer.

Calves were weighed on entry to the trial site and then weekly, to calculate their average daily gain (ADG). At every feeding, the time for each individually housed calf or group of calves to

consume the colostrum, half colostrum or whole milk was measured. The trial was conducted to Kaiawhina Animal Ethics Standards, New Zealand (approval code AEC005/14). Full trial biosecurity was afforded by the use of wheel and footbaths containing animal-safe, long lasting disinfectants (Credence, Kiotech-Agil Ltd, UK).

Data was analysed using the general linear model procedure of Unistat (UNISTAT 5.5, London, UK), with confidence limits set at 5% ($P<0.05$). For average daily gain, body weight at day old was used as a covariate to eliminate its potential influence on subsequent performance. In addition, the dataset for milk intake was analysed for the whole trial period and split by feeding phase: colostrum only (days 1-5 of age), half colostrum and half whole milk (6-12 days old) and whole milk only (from day 13 to the end of the trial).

RESULTS

Results for milk intake showed that those fed using medium release teat calfeterias had significantly shorter consumption time compared to those calves on the slow release teats (Table 1), with the medium teat fed calves consuming milk twice as fast as those fed using slow teats (2.1 min/l versus 4.2 min/l; $P<0.0001$) for the whole period. When broken down into the three feeding phases, those on the slow teats consumed milk at a rate of 5.7 min/l versus 3.2 min/l during the colostrum phase (which includes the calfeteria training period where calves were slower to consume the milk). For the half colostrum, half milk phase, intake times were 2 min/l for medium teats and 4.2 min/l for slow teats. For the whole milk feeding period (days 13-42) consumption rates were 1.8 min/l for medium and 3.3 min/l for slow teats. Meal intake was not significantly higher between treatments, although those on the slow teat feeders were slightly numerically higher (Table 1).

Body weights and daily gains, when including day old body weight as a covariate, showed no initial significant differences. However, at 42 days of age, calves fed using the slow teats had a strong trend for higher average daily gains (0.738 kg/d slow teats versus 0.665 kg/d medium teats; P=0.0758). This may reflect the differences in digestibility observed during the dissection of the stomach.

For samples from the cull calves, there were no significant differences seen in digestibility between the calves fed using the slow release and medium release teats at seven days of age (Table 2). However, at 14 days of age, the calves fed using the slow release teats had significantly (P=0.0338) higher lactose disappearance in the stomach and a trend (P=0.0718) towards higher ileal available protein compared to the calves fed using the medium teats.

Photographic evidence showed consistent differences between those fed using the medium versus the slow release teats (Figures 1 and 2 below). The medium teat fed calves had large clots of curded milk surrounded by watery fluid in the main chamber of the undeveloped, simple stomach. However, in the calves reared using the slow release teats, the ingested milk was curded into much smaller, uniform pieces surrounded by a thicker liquid. These characteristics were consistent for both the seven and 14 day olds calves. This indicated that initial digestion in those fed with slow teats had much larger surface area of the consumed milk during the first stage of digestion (i.e. reaction with rennet in the simple stomach). This may directly reflect the slower, regular flow of milk into the calf – which is then interacted with rennet in smaller, more discreet aliquots. Overall, it would be logical to expect that such a larger and more regular surface area may be related to rate of digestion in the upper intestines.

During the trial, it was observed that group-housed calves fed the medium flow teats had a much greater incidence of hyperactivity immediately post feeding and were more likely to engage in non-nutritive sucking of each other's body parts (including muzzle, navel and udder). Although this was not the focus of the current trial and hence was not monitored in terms of occurrence or duration, further research is warranted into these observations.

Discussion

The data showed that feeding a medium or slow release teat had a significant impact on consumption speed, which was related to the age/feeding phase, and in the coagulation characteristics of milk in the immature stomach of calves. Other researchers have previously reported such differences in ingestion time – although these were via other suckling systems and varied from the design and control of the teats used in this experiment (Haley *et al.*, 1998; Herskin *et al.*, 2010). The slow feeding teats increased consumption time by double that seen in the medium feeding teats for the whole period. In addition, this appeared to have an effect on initial digestion via coagulation with rennet, whereby calves fed with the medium release teats developed large coagulated clots of milk in watery fluid two hours post feeding, whereas the slow teat fed calves have a more 'porridge-like' consistency of small coagulated fragments within a thicker fluid. However, there is little or no published information regarding the relationship between speed of intake and milk coagulation, so it is not possible to compare this against other trials, or to determine an optimal speed for milk coagulation, surface area and digestion. The calves fed using the slow teats had higher lactose disappearance in the stomach and a trend towards higher protein in the ileum which may be related to one another, indicating that feeding speed and curding characteristics had an impact on milk digestibility. These differences may be due to slow feeding eliminating 'overfill' in the immature abomasum, as discussed by Radostits and Bell (1970) and Blowey (2008), as well as negating the flow of

undigested ‘by–pass’ milk nutrients into the lower intestines (Porter, 1969; Blowey, 2008). In addition, the calves fed using the slow teats had higher ADG when calculated from 1-42 days of age, which may be attributed to the higher digestibility of lactose as a primary energy source seen in the calves fed using the slow flow teats.

Conclusions

Using slow delivery teats to feed calves from day old to weaning appears to have an important impact on digestive processes in the immature gut. This may be responsible for the strong trend seen in the 42 d ADG. Although meal intake only showed small numerical advantages in the slow teat-fed calves, improvements in digestion and rumen development in young calves may also assist in the digestion of other feeds, apart from milk, and may have further impacts on performance at weaning and during maturation. It may be that using this novel, slow release teat system can be expected to reduce scours and other digestive problems in young calves during peak milk intake (up to 15 d of age).

The digestibility results indicated that future studies need to focus on 14 day old calves where important differences were seen despite the fact that this study only had three calves per treatment. From this study further research is warranted to determine how milk curding differences occur between the slow and medium teat fed calves in order to understand the consistent differences seen in coagulation particle sizes observed. In addition, future trials should include monitoring the behavioural element of suckling speeds from calfeterias.

References

Albright, J.L., and Arave, C.W. (1997). The behavior of cattle. CAB International, Wallingford, UK.

200 Appleby, M.C., Weary, D.M., and Chua, B. (2001). Performance and feeding behavior of
201 calves on ad libitum milk from artificial teats. *Applied Animal Behaviour Science* **74**
202 (3): 191-201.
203 Blowey, R.W. (2008). Digestive disorders of calves. Pages 231-238 in Bovine Medicine:
204 Diseases and Husbandry of Cattle. 2nd Ed. A.H. Andrews, R.W. Blowey, I. Boyd and
205 R.G. Eddy, ed. John Wiley and Sons, NJ, USA.
206 de Passillé, A.M.B. (2001). Sucking motivation and related problems in calves. *Applied Animal*
207 *Behaviour Science*. **72**: 175-187.
208 Frantzen, J., Toullec, R., Thivend, P., and Mathieu, C.M. (1973). Influence de la coagulation
209 des proteins sur la vidange stomacale chez le veau pre ruminant. *Annals of Biology*
210 *Animals Biochemistry and Biophysics*. **13**: 718.
211 Haley, D.B., Rushen, J., Duncan, I.J.H., Widowski, T.M. and de Passille, A.M. (1998). Effects
212 of resistance to milk flowand the provision of hay on nonnutritive sucking by dairy
213 calves. *Journal of Dairy Science*. **81**:2165-2172.
214 Herskin, M.S., Skjoth, F. and Jensen, M.B. (2010). Effects of hunger level and tube diameter
215 on the feeding behavior of teat-fed dairy calves. *Journal of Dairy Science* **93** (5):2053-
216 2059.
217 Jasper, J., and Weary, D.M. (2002). Effects of ad libitum milk intake on dairy cows. *Journal*
218 *of Dairy Science* **85**: 3054-3058.
219 Jensen, M.B. (2003). The effects of feeding method, milk allowance and social factors on milk
220 feeding behavior and cross-sucking in group housed dairy calves. *Applied Animal*
221 *Behavior Science* **80** (3): 191-206.
222 Jensen, M.B., and Budde, M. (2006). The effects of milk feeding method and group size on
223 behavior and cross-sucking in group-housed dairy calves. *Journal of Dairy Science* **89**
224 (12): 4778-4783.

225 Jung, J., and Lidfors, L. (2001). Effects of amount of milk, milk flow and access to a rubber
226 teat on cross-sucking and non-nutritive sucking in dairy calves. *Applied Animal*
227 *Behavior Science* **72** (3): 201-213.
228 Longenbach, J.I., and Heinrichs, A.J. (1998). A review of the importance and physiological
229 role of curd formation in the abomasums of young calves. *Animal Feed Science and*
230 *Technology* **73** (1-2): 85-97.
231 Margerison, J.K., Preston, T.R., Berry, N. and Phillips C.J.C. (2003). Cross-suckingand other
232 oral behaviours in calves and their relation to cow suckling and food provision. *Applied*
233 *Animal Behavior Science* **80**: 277-286.
234 Porter, J.W.G. (1969). Digestion in the pre-ruminant animal. *Proceedings of the Nutrition*
235 *Society* **28** (1): 115-121.
236 Radostits, O.M., and Bell, J.M. (1970). Nutrition of the pre-ruminant dairy calf with special
237 reference to the digestion and absorption of nutrients: a review. *Canadian Journal of*
238 *Animal Science* **50**:405-452.
239 Smith, R.H., and Sissons, J.W. (1975). The effect of different feeds, including those containing
240 soya-bean products, on the passage of digesta from the abomasum of the prereuminant
241 calf. *British Journal of Nutrition* **33**: 329-349.
242 Strudsholm, F. (1988). The effect of curd formation in the abomasum on the digestion of milk
243 replacers in preruminant calves. *Acta Agricultura Scandinavia* **38** (3): 321-327.
244 Ternouth, J.H., and Roy, J.H.B. (1973). The effect of diet and feeding technique on digestive
245 function in the calf. *Annals of Veterinary Research* **4** (1): 19-30.
246 Wise, G.H., and Lemaster, J.P. (1968). Response of calves to open-pail and nipple-pail
247 systems. *Journal of Dairy Science* **51**: 452-456.
248

249 **Table 1.** Milk and meal intake of calves fed using either medium or slow teat delivery systems

Parameter	Medium Teat	Slow Teat
Whole period min/l	2.1[a]	4.2[b]
Colostrum min/l	3.2[a]	5.7[b]
50/50 min/l	2.00[a]	4.2[b]
Whole milk min/l	1.8[a]	3.3[b]
Meal intake calf/d kg	0.165[a]	0.167[a]
Meal intake/pen kg	1.383[a]	1.52[a]

250 [a,b] Means within a row with different superscripts differ significantly (P<0.0001)

251

252 **Table 2.** Digestibility in calves at 7 and 14 days of age fed using either medium or slow teat

253 delivery systems

Parameter	Calf Age	Units	Medium Teat	Slow Teat	P value
Protein stomach	7	%	12.9	16.5	0.6497
Lactose disappearance stomach	7	%	74.3	80.0	0.5606
Protein ileum	7	%	6.4	6.3	0.9615
Lactose disappearance ileum	7	%	79	82.3	0.8485
Protein rectum	7	%	20.8	19.17	0.5984
Lactose disappearance rectum	7	%	99.0	98.7	0.6667
Protein stomach	14	%	10.6	7.3	0.1528
Lactose disappearance stomach	14	%	71.7[a]	92[b]	0.0338
Protein ileum	14	%	5.7	8.3*	0.0718
Lactose disappearance ileum	14	%	75.0	85.0	0.1647
Protein rectum	14	%	11.0	13.0	0.3765
Lactose disappearance rectum	14	%	98.3	99.3	0.1012

254 [a,b] Means within a row with different superscripts differ significantly ($P<0.05$)

255 *Denotes strong trend

256

Figure 1. A calf fed using medium flow milk teat at 7 days of age; large clots of coagulated milk in watery fluid

Figure 2. A calf fed using slow flow milk teat at 7 days of age; smaller clots of coagulated milk in thicker fluid