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The Effects of Continuous or Intermittent Infusion of Propionic Acid on Plasma Insulin and Milk Yield in Dairy Cows Nourished by Intragastric Infusion of Nutrients

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ABSTRACT

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Four experiments were conducted with lactating dairy cows nourished by infusion of a mixture of acetic, propionic and butyric acids into the rumen, and infusion of casein into the abomasum. All infusates were either infused continuously, so as to simulate ad libitum feeding of a completely mixed diet, or part of the propionic acid was infused in two 3-h pulses at 12 h intervals, with the remainder of the propionic acid and the other acids and casein infused continuously. This second method of infusion was intended to simulate the feeding of concentrate twice daily.

Plasma insulin peaked twice daily with the pulsed infusion of propionic acid.

Milk yield was maintained with animals sustained by intragastric infusion when a small amount of fibrous food was offered and the environmental temperature was maintained at about 22°C. The method of infusing propionic acid had no consistent effect on milk yield, milk fat concentration or fat yield. The pulses of propionic acid did not increase the concentration of C_{15} and C_{17} fatty acids in milk lipids.

INTRODUCTION

With normally fed dairy cows, concentrates are given either as discrete meals, usually with continuous access to roughage, or as a complete diet, with the concentrate incorporated with the roughage and continuous access to the mixture. Differences in the method of feeding can affect the relative proportions of the volatile fatty acids (VFA) absorbed and this in turn can affect the partition of energy between body tissue and milk (Hart, 1983; Sutton et al., 1986).

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Since not only glucose and amino acids but also propionic and butyric acids (Bassett et al., 1971; Ambo et al., 1973; de Jong, 1982) are potential stimulants of insulin secretion in the rumen, it is assumed that the effect on the partition of energy is mediated by changes in insulin secretion.

The object of the study reported here was to study the effect of different patterns of nutrient infusion on plasma insulin and milk production. A series of four experiments were conducted with lactating dairy cows nourished by the intragastric infusion of VFA and protein (Orskov et al., 1979; MacLeod et al., 1982). The treatments were designed to simulate the feeding of concentrates mixed in a complete diet, or given as discrete meals.

MATERIALS AND METHODS

Animals, infusion procedure and experimental design

Preliminary experiment

Two Friesian cows in their fourth week of lactation were used in six experimental periods.

During Periods 1–4 (each of 5 days), the animals were nourished by intragastric infusion and during Periods 5 and 6 (each of 21 days) they were offered normal diets. Intragastric nourishment was administered by the method of MacLeod et al. (1982) in which VFA are infused into the rumen and casein into the abomasum. The cows were infused with a mixture of VFA containing, expressed as molar proportion, 0.65 acetic, 0.25 propionic and 0.10 butyric acids (low propionic acid infusion) during Periods 1 and 2 and with 0.58 acetic, 0.32 propionic, 0.10 butyric acids (high propionic acid infusion) during Periods 3 and 4. During one 5-day period, the VFA were all infused continuously (C) to simulate the feeding of a completely mixed diet. In the other period 0.46 (Periods 1 or 2) or 0.38 (Periods 3 or 4) of the daily ration of propionic acid was infused as two equal pulses (P) of 3 h duration (11.00 h–14.00 h and 23.00 h–02.00 h) to simulate the intermittent feeding of concentrate. The total amount of propionic acid pulsed in this way was equivalent to 0.15 of total energy supplied by the VFA, which was not changed. During the initial adaptation to intragastric infusion one cow showed signs of discomfort with a rapid drop in milk yield. During this time environmental temperatures were low, sometimes below 0 °C. A fan heater blowing over the cows was used to raise air temperature and the cows were given 1.2 kg day^{-1} of ammonia-treated straw (100 g every 2 h). Milk yield was restored.

In Periods 5 and 6, the cows were reintroduced to solid food, a mixture of hay (0.35) and concentrate (0.65). The concentrate consisted of 0.75 barley, 0.12 soya bean meal, 0.04 fish meal, 0.05 molasses, 0.035 minerals and 0.005 urea. Metabolisable energy (ME) intake was similar to the gross energy infused during Periods 1–4. During Period 5 one cow was given the hay and concentrate

TABLE I

Daily amount of casein and VFA infused, and solid food offered and eaten

Experiment	Period	Volatile fatty acids (kg)	Casein (kg DM)	Gross energy supplied by infusates (MJ)	Type of feedstuff	Offered (kg DM)	Eaten (kg DM)
Preliminary	1–2	4.6	1.62	120.4	Ammonia-treated straw	1.1	1.1
	3–4	4.5	1.62	120.7	Ammonia-treated straw	1.1	1.1
	5–6	—	—	100.0[a]	Hay and concentrate	10.7	10.7
1	All[b]	4.9	1.22	118.4	Ammonia-treated straw (0.5) and sugar beet pulp (0.5)	4.7	4.3
2	All[b]	4.6	1.28	113.2	Hay (0.3), dried grass (0.3) ammonia-treated straw (0.2) and sugar beet pulp (0.2)	2.0	1.8
3	All[b]	4.8	1.06	112.9	Ammonia-treated straw	ad libitum	2.0

[a]Calculated ME intake of the conventional diet normally fed.
[b]All infusion periods.

completely mixed while she was offered the concentrate component as separate meals at 08.00 h and 20.00 h in Period 6. The other animal was allocated the same treatments in the reverse order.

The 6 periods were divided into three groups for statistical analysis: Periods 1 and 2 when the cows were infused with a mixture low in propionic acid, Periods 3 and 4 with a mixture high in propionic acid and Periods 5 and 6 with cows normally fed. The differences between these 3 groups of periods were tested assuming randomized complete blocks in which the cows corresponded to two blocks. The treatments were tested against within animal, within period variation.

Experiments 1, 2 and 3

These experiments were carried out with a total of six cows, all nourished by intragastric infusion, but offered some solid food (Table I). The cows used for Experiments 1 and 2 were in their first and second months of lactation while the two cows used in Experiment 3 were in their sixth month of lactation. The infusion procedure was in general similar to that used in the preliminary experiment. The experimental periods lasted 14, 14 and 10 days in Experiments 1, 2 and 3 respectively, with the exception of Period 3 of Experiment 1 (2 animals) and 2 (1 animal), which was extended to 21 days. The molar proportions of VFA were 0.650 acetic, 0.175 propionic and 0.175 butyric acids, similar to those measured in vivo during Periods 5 and 6 of the preliminary experiment (normal feeding). Two treatments were used in each experiment: either continuous infusion or part of the propionic acid in pulses, as in the preliminary experiment. The total propionic acid pulsed was again equivalent to 0.15 of total energy supplied daily by the VFA and represented 0.67, 0.70 and 0.69 of the total propionic acid in Experiments 1, 2 and 3, respectively. Based on the experience of the preliminary experiment, care was taken to ensure that room temperature was maintained at approximately 22°C. During Experiments 1 and 2, the tubes containing the infusates were led through a heated water bath and infrared lamps were suspended over the animals. Some solid food was offered to the animals.

In Experiment 3 the cows were infused according to a change-over design. Experiments 1 and 2 were similar but with an extra period added which repeated the treatments imposed in Period 1. The treatment effects were therefore not fully balanced for animal effects and the values derived for Fig. 2 were adjusted for animal effect. The effect of the 3-h pulses of propionic acid on milk fat concentration was compared for individual cows using a "*t*" test.

Measurements

Milk production was recorded every day. Samples from morning and afternoon milk were taken for analysis during the last 4 (preliminary experiment), 5 (Experiment 3) or 7 days (Experiments 1 and 2) of each period. Milk fat for fatty acid analysis was taken from the afternoon milk on the last day of Periods 1 and 2 in Experiments 1 and 2. This sample was chosen so as to minimise the time (2 h) between the end of the pulses of propionic acid and the time the cows were milked. At the end of each period of the preliminary experiment and Experiments 1 and 2, blood samples were withdrawn from the jugular vein every 2 h for two consecutive days. In Experiment 2, the apparent digestibility of the solid food on offer was determined by total collection of faeces over a period of 7 days.

Chemical analysis

Fat concentration in the milk was determined by the Gerber method (Ling, 1949). Milk fatty acids were extracted by the method of Folch et al. (1957). Fatty acid butyl esters were prepared and analysed by capillary column gas chromatography (Smith et al., 1979). Plasma samples were analysed for glucose by the method of Trinder (1969) and for insulin by radioimmunoassay (Bassett and Thorburn, 1971). The minimum detection limit of the insulin assay was 3.5 mu l^{-1} with intra- and interassay coefficients of variation 0.055

and 0.08 respectively. Plasma samples obtained at 11.00, 14.00, 23.00 and 02.00 h during the preliminary experiment were analysed for VFA by a free transfer and gas chromatographic technique. The method used was a modification of that described by Ribeiro (1979), based on the procedure of Pethick et al. (1981).

RESULTS

The average daily amounts of VFA and casein infused in the four experiments are given in Table I. The total gross energy from the infusates ranged from 113 to 121 MJ day^{-1}.

Preliminary experiment

Plasma insulin and metabolites

Plasma insulin concentration was relatively constant over the 24 h during the continuous infusion periods (Fig. 1). In contrast, when giving a pulse of propionic acid, the maxima in insulin coincided with the end of the infusion pulse (Fig. 1a, b). When the animals were fed normally, there were no clear changes in plasma insulin, whether or not concentrates were given as a separate meal (Fig. 1c).

Over a 24-h period the average values for plasma insulin of the two cows were 23.0, 28.5 and 14.6 mu l^{-1} when the animals were on continuous infusion with a low proportion of propionic acid in the VFA mixture, a high proportion of propionic acid and when offered solid food. The differences between periods on infusion and on normal feeding were significant ($P<0.01$). The concentrations of plasma insulin, glucose and VFA before and at the end of the pulses of propionic acid are given in Table II. At the end of the pulses, the concentration of plasma insulin was increased by about three times, that of plasma propionic acid was increased six-fold; there were also increases in acetic and butyric acid concentrations. There was a tendency for plasma glucose to decrease.

Milk production

Milk yield and milk composition are given in Table III. During the four infusion periods daily milk yield decreased by about 0.8 kg day^{-1}. During Periods 5 and 6, when the cows were normally fed, the milk yield remained constant and averaged 9 kg day^{-1}. Fat concentration was lower ($P<0.05$) during the four infusion periods at about 25 g kg^{-1} than during the succeeding periods with normal feeding (at 34 g kg^{-1}). Fat yield tended to increase during the period of normal feeding. The nitrogen content was on average 5.83 g kg^{-1} and was not affected by the method of infusion.

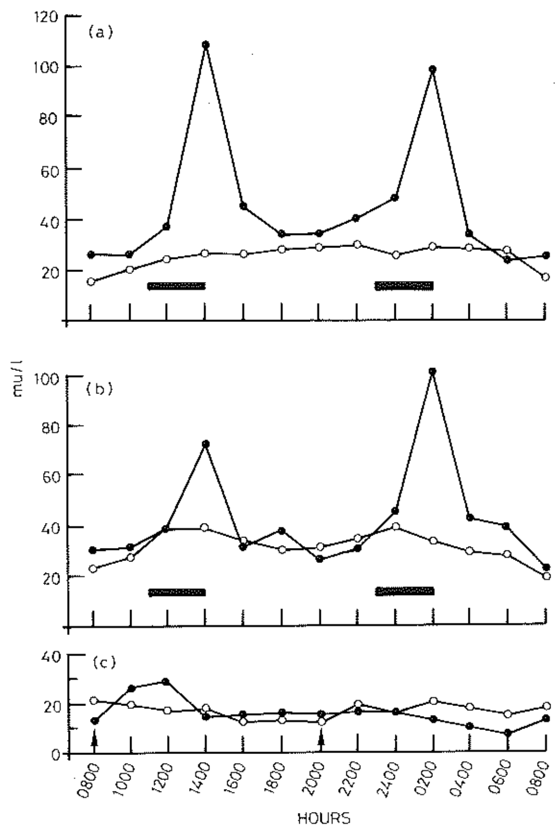

Fig. 1. Preliminary experiment. Plasma insulin concentration in cows infused either continuously (O) or with 0.15 of the daily energy from VFA as propionic acid in pulses (●) of 3-h duration (▬). Figure 1a refers to Periods 1 and 2 (low propionic acid infusion) and Fig. 1b to Periods 3 and 4 (high propionic acid infusion). The comparison is made with the insulin concentration found in cows fed concentration twice daily (↑) or a mixed diet (Fig. 1c).

TABLE II

Preliminary experiment. Concentration of insulin, glucose and volatile fatty acids in the plasma before and at the end of the pulses of propionic acid

	Before the pulse	End of the pulse
Insulin (mu l^{-1})	31.9 ±11.4	94.6 ±33.3
Glucose (mg l^{-1})	699 ±58	684 ±44
Acetic acid (mmol l^{-1})	1.775± 0.585	2.489± 0.627
Propionic acid (mmol l^{-1})	0.039± 0.026	0.228± 0.098
Butyric acid (mmol l^{-1})	0.018± 0.009	0.026± 0.014

TABLE III

Preliminary experiment. Effect on milk yield and composition of the infusion of propionic acid continuously or with 0.15 of the daily energy from infused VFA given as propionic acid in two equal pulses of 3 h duration compared with performances in cows normally fed

	Milk yield (kg day⁻¹)	Fat		Nitrogen	
		Concentration (g kg⁻¹)	Yield (g day⁻¹)	Concentration (g kg⁻¹)	Yield (g day⁻¹)
Infusion with low propionic acid (Periods 1-2)					
Continuous infusion	16.9	26	430	5.59	93.9
Pulses of propionic acid	12.8	27	339	5.59	72.1
Infusion with high propionic acid (Periods 3-4)					
Continuous infusion	8.7	25	220	6.12	53.9
Pulses of propionic acid	9.5	24	228	6.11	57.4
Cows normally fed (Periods 5 and 6)					
Completely mixed diet	9.0	32	284	5.89	53.6
Concentrate give twice daily	8.9	36	310	5.68	50.0
SED (3df)	1.44	2.65	15.9	0.130	5.55

Experiments 1, 2 and 3

Plasma insulin

The diurnal variations in plasma insulin in Experiments 1 and 3 are given in Fig. 2. The overall pattern was similar to that observed in the preliminary experiment when the cows were infused.

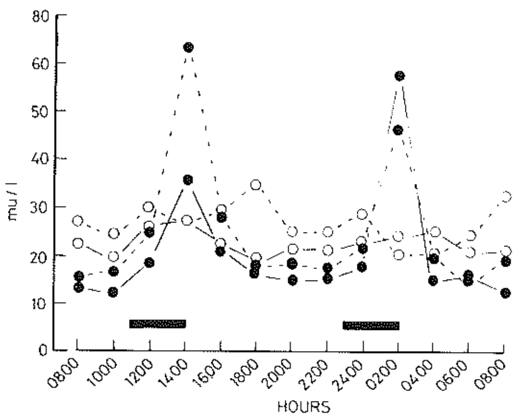

Fig. 2. Experiments 1 and 3. Effect on plasma insulin of the infusion of propionic acid continuously (O) or 0.15 of the daily energy from VFA as propionic acid in two equal pulses (●) of 3-h duration (▬). Experiment 1 (——), Experiment 3 (-----).

TABLE IV

Effect on milk yield and milk fat of the infusion of propionic acid continuously (C) or with 0.15 of the daily energy from infused VFA given as propionic acid in two equal pulses of 3 h duration (P)

	Treatment			Milk yield (kg day $^{-1}$)			Fat concentration (g kg $^{-1}$)			Fat yield (g day $^{-1}$)		
Experiment 1, early lactation	Cow A	Cow B		Cow A	Cow B		Cow A	Cow B		Cow A	Cow B	
Period 1	P	C		22.7	27.1		31	35		726	932	
Period 2	C	P		19.9	25.3		32	29		635	733	
Period 3 Week 2	P	C		17.6	22.4		31	29		537	659	
Week 3	P	C		16.2	20.0		31	28		503	564	
Pooled SE				0.48			1.2			33.6		
Experiment 2, early lactation	Cow C	Cow F	Cow G	Cow C	Cow F	Cow G	Cow C	Cow F	Cow G	Cow C	Cow F	Cow G
Period 1	C	C	P	26.3	21.9	20.5	48	33	34	1250	727	693
Period 2	P	P	C	26.6	19.9	20.9	42	29	32	1114	580	669
Period 3	C	C	P	24.6	19.3	21.3	41	27	31	1011	523	651
Pooled SE				0.40			1.1			34.7		
Experiment 3, late lactation	Cow C	Cow D		Cow C	Cow D		Cow C	Cow D		Cow C	Cow D	
Period 1	C	P		12.5	9.2		36	42		453	388	
Period 2	P	C		11.4	8.1		37	40		418	327	
Pooled SE				0.27			1.2			15.9		

Milk production

The sequences of the treatments, the milk yield, fat concentration and fat yield of all three experiments are given in Table IV. In Experiments 1, 2 and 3, milk yield was maintained at a relative high level with an average decline of about 0.1 kg day^{-1}. Solid food, as indicated by the performances from Cow C in Experiment 2, appeared to be of importance to maintain milk yield. Initially 2.0 kg of dry matter (DM) of solid food was offered daily but at the beginning of the second week of Period 3, the food offered was gradually reduced over eight days to 1.0 kg DM day^{-1}. On Day 9, milk yield decreased suddenly by 4.3 kg from 25.0 to 20.7 kg day^{-1}. Solid food was restored to 2 kg DM day^{-1}; on the following day, milk yield was 26.5 kg and remained at about 25.0 kg over the following days. Since the objective of the experiment was to characterize the effect of pulses of propionic acid on milk composition, no further attempts were made to reduce solid food intake.

In Experiments 1 and 2, with animals in early lactation, milk fat concentration and yield significantly decreased ($P<0.05$) for Cows B, C and F which were given the pulses in Period 2 after the continuous infusion of Period 1; when continuous infusion was re-introduced in Period 3, there was no recovery of milk yield, fat concentration or fat yield. Milk fat concentration was not increased by the imposition of continuous infusion in Cows A and G, which had started the infusion procedure with pulses of propionic acid. In Experiments 1 and 2, there were five changes from continuous infusion to pulsed infusion of propionic acid and five changes in the reverse direction. In both cases, fat yield decreased, when expressed as a proportion of the fat yield in the preceeding period, by 0.14 and 0.09, respectively. Milk fat concentration was not affected by the method of infusing propionic acid in Experiment 3 with cows in late lactation. There were therefore no clear effects of method of infusion on fat yield.

The overall mean concentration for the milk fatty acids (Experiments 1 and 2) was 303, 467 and 217 g kg^{-1} total fatty acid for the C_{4-15}, C_{16}-C_{17} and C_{18} fatty acid groups, respectively. The method of infusion did not influence either the proportions of the different groups, or the proportions of the C_{15} and C_{17} fatty acids, the overall mean of which was 9 g kg^{-1}.

Apparent digestibility of solid food

The apparent digestibility of the solid food offered in Experiment 2 was 522 ± 43 g kg^{-1} for dry matter and 600 ± 50 g kg^{-1} for organic matter. Solid food contributed an estimated 17 MJ day^{-1} while that of the infusate amounted to 113 MJ day^{-1}.

DISCUSSION

Pattern of plasma insulin

The finding that peaks of plasma insulin followed the pulses of propionic acid infusion is in agreement with other results reported from this laboratory

(Istasse et al., 1985), in which the increase in plasma insulin was associated with an increase in plasma propionic acid and not related to changes in plasma glucose. Similar effects were observed in the preliminary experiment reported here where at the end of pulse plasma propionic acid was 0.228 mmol l^{-1} compared with 0.039 mmol l^{-1} before the pulse. The corresponding values for plasma glucose were 684 and 699 mg l^{-1}. It is postulated that during the pulses of propionic acid the liver became overloaded and some of the propionic acid escaped metabolism. This spill-over of propionic acid then entered the peripheral blood giving rise to the elevated concentration observed (Table II) and stimulated insulin production by the pancreas. This does not necessarily imply a direct effect of propionic acid on the pancreas. There may also have been a glucagon release which in turn would have stimulated insulin secretion (Bassett, 1974). With the infusion of propionic acid in pulses, a small increase in the concentration of butyric acid in the peripheral plasma was also observed (Table II). Since butyric acid is a powerful stimulus to insulin secretion (Bassett et al., 1971; Ambo et al., 1973; de Jong, 1982), part of the insulin response may have originated from the increase in butyric acid concentration.

The pattern of plasma insulin in the preliminary experiment and in Experiments 1 and 3 (Figs. 1 and 2) was similar to that reported by Sutton et al. (1983) with normally fed cows (cited by Hart, 1983). In their work, insulin peaked two or six times daily, reflecting the frequency of feeding of the concentrate. We did not observe such a pattern when our cows were fed normally (Fig. 1). In a recent experiment, Sutton et al. (1986) also observed that more frequent feeding of the concentrate (six vs. two times daily) reduced the mean daily concentration of insulin from 20.8 to 10.4 mu ml^{-1} with cows in early lactation and from 34.8 to 18.4 mu ml^{-1} in a later stage.

Milk yield and total infusion

A rapid decline in milk yield was observed during the periods of infusion in the preliminary experiment. By contrast, milk yield declined only slowly, conforming to a more normal pattern with the advance of lactation in the other experiments. It is not easy to determine whether the changes in procedure adopted during Experiments 1, 2 and 3 (compared with the preliminary experiment) were responsible for the improved maintenance of milk yield. In the preliminary experiment cold stress was initially suspected as the primary factor in the rapid decline in milk yield. The heat of fermentation in the rumen and the heat generated by gut activity are necessarily low in animals nourished by intragastric infusion. It is possible that by increasing environmental temperature and warming the infusates, the stress imposed by cold was diminished. However, it is also possible that the allocation of small amounts of solid food may have had an effect in the maintenance of milk yield. Table III illustrates how the decline in milk yield in the preliminary experiment was halted when normal feeding was resumed, and how milk fat yield actually increased. Circumstantial evidence which supports the concept that solid feed per se may be of importance was provided by our experience in Experiment 2 with Cow C, whose milk yield dropped suddenly when 1 kg of solid food was offered but was restored the day after 2 kg were given. The energy balance was calculated considering the energy of the infused nutrients as ME. The ME required for maintenance was assumed to be 0.450 MJ $kg^{-0.75}$. The energy content of the milk was calculated using the relationship of Tyrrel and Reid (1965), $E=40.6 F+1509.0$, where E = energy in KJ kg^{-1} of milk and F = fat content in g kg^{-1}. During the infusion periods of the preliminary experiment the average energy deficit was 40.0 MJ, while it was 35.4, 42.0 and −7.9 MJ day^{-1} in Experiments 1, 2 and 3 respectively. In Experiment 2 solid food contributed an estimated 17 MJ day^{-1} of ME, equivalent to about 0.15 of the energy supplied by the infusates. It is unlikely therefore that the energy contribution of the solid food was responsible for the maintenance of milk yield compared with the decline in the preliminary experiment. Nor are there any obvious nutrient deficiencies in the infusates. The cows had normal oestrus cycling, and those which were inseminated conceived at first insemination. It therefore seems possible that the physical response of the solid food may have stimulated some response important for the maintenance of lactation.

Milk fat yield and composition

Not only was milk yield not maintained during the infusion periods of Experiment 1, but fat concentration was nearly 10 g kg^{-1} lower than during Periods 5 and 6 when the animals were conventionally fed. This low milk fat concentration may have been associated with the higher plasma concentration of insulin; even on continuous infusion plasma insulin tended to be higher than with normal feeding.

The intermittent infusion of propionic acid produced a diurnal pattern of plasma insulin similar to that obtained with frequent feeding of normal diets (Hart, 1983). Milk fat concentration decreased only in early lactation when the cows were infused in Period 2 with the pulses of propionic acid, but there were no clear overall effects on milk fat yield. This is in contrast to the results of Sutton et al. (1983, 1986) who reported an increase in milk fat concentration when the frequency of feeding with the concentrate was increased from two to six times daily. One of the differences between the work of Sutton et al. (1983) and the present infusion experiments, was that the periods of high insulinaemia resulting from pulsed infusion of propionic acid were of shorter duration than with two meals daily. Therefore the diversion of nutrients away from the mammary gland may have been less extended. Furthermore, with conventionally fed ruminants one could expect an increase of all energy yielding nutrients during the postprandial phase of meal feeding and not of propionic acid alone. Storry and Sutton (1969) reported a conventional feeding trial in which dairy cows were changed from a high concentrate diet which depressed milk fat concentration to a diet higher in roughage. They showed that fat concentration did not fully recover until three weeks after changing diets and two weeks after VFA changes in the rumen were complete. Thus a possible interpretation of our own results is that the periods were not long enough to demonstrate recovery.

The fact that no effect was found on the composition of milk fat is in contrast with the results of Lough et al. (1983) who infused cows with VFA mixtures of varying molar proportions. As the proportion of propionic acid was increased, so the concentration of odd-numbered fatty acids in milk fat increased. The major difference between the work of Lough et al. (1983) and the present experiments was that in the present trials the amounts and the molar proportions of VFA given during 24 h were identical for the different treatment periods.

Although the induction of pronounced changes on the pattern of plasma insulin was without effect on milk composition, the experiments reported here were unable to elucidate the reason. However, circumstantial evidence suggested that the maintenance of high levels of milk production may require more than the simple provision of nutrients. Thus when care was taken to reduce heat losses and to provide small amounts of solid food milk yields in excess of 20 kg day^{-1} could be maintained by the intragastric infusion of 0.85 of energy as VFA.

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RESUME

Istasse, L., Hovell, F.D.DeB., MacLeod, N.A. and Orskov, E.R., 1987. Effets de l'infusion continue ou intermittente d'acide propionique sur la teneur en insuline dans le plasma sanguin et sur la production laitière chez des vaches nourries par la technique d'infusion intragastrique de nutriments. *Livest. Prod. Sci.*, 16: 201-214 (en anglais).

Un ensemble de 4 expériences a été réalisé avec des vaches laitières nourries par la technique d'infusion totale. Cette technique consiste en l'infusion d'un mélange des acides acétique, propionique et butyrique dans le rumen et de caséine dans la caillette. Toutes les solutions étaient soit infusées en continu de manière à simuler la distribution ad libitum d'une ration complètement mélangée ou soit avec une partie de l'acide propionique infusée sous forme de 2 impulsions de 3 heures chacune et répétées à intervalles de 12 heures; les autres acides et la caséine étant infusés continuellement. Ce second mode d'infusion était destiné à simuler la distribution du concentré 2 fois par jour.

La concentration en insuline dans le plasma sanguin a présenté 2 pics par jour lors de l'infusion en impulsion de l'acide propionique.

La production laitière a été maintenue chez ces animaux nourris par infusion intragastrique lorsque une faible quantité d'aliments fibreux était à leur disposition et que la température ambiante était maintenue à environ 22°C. Le mode d'infusion de l'acide propionique n'a pas eu d'effets constants sur la production laitière, la teneur en matière grasse ou la quantité de matière grasse. L'infusion d'acide propionique en impulsion n'a pas augmenté la teneur des acides gras C_{15} et C_{17} dans les lipides totaux du lait.

KURZFASSUNG

Istasse, L., Hovell, F.D.DeB., MacLeod, N.A. and Orskov, E.R., 1987. Die Wirkung einer kontinuierlichen oder unterbrochenen Infusion von Propionsäure auf den Plasma-Insulinspiegel und die Milchleistung von Kühen bei intragastraler Ernährung. *Livest. Prod. Sci.*, 16: 201–214 (auf englisch).

Es wurden vier Versuche durchgeführt, in denen laktierende Kühe durch Infusion von Essigsäure, Propionsäure und Buttersäure in den Pansen bei gleichzeitiger intragastraler Infusion von Casein ernährt wurden. Die Infusionen wurden zum einen — als Simulation einer ad libitum-Fütterung — kontinuierlich vorgenommen. Daneben wurde — zur Simulation einer zweimal täglichen Verfütterung von Konzentraten — ein Teil der Propionsäure in zweimaligen Schüben über jeweils drei Stunden in fünfstündigen Intervallen bei kontinuierlicher Infusion der Restmengen an Propionsäure sowie der anderen Säuren und des Caseins verabfolgt.

Der Plasma-Insulinspiegel zeigte bei der unterbrochenen Infusion der Propionsäure zwei tägliche Maxima.

Die Milchleistung der durch die intragastralen Infusionen ernährten Milchkühe wurde aufrecht erhalten, wenn eine geringe Menge faserhaltigen Futters angeboten und die Umgebungstemperatur bei etwa 22°C gehalten wurde. Die beiden unterschiedlichen Methoden der Infusion von Propionsäure hatten keinen erkennbaren Effekt auf Milchleistung, Milchfettgehalt und Milchmenge. Die Gehalte an C_{15} und C_{17} Fettsäuren im Milchfett waren durch die schubweise Verabreichung der Propionsäure nicht erhöht.

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