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# MEASUREMENT OF THE MILK CONSUMPTION OF SUCKLING BEEF CALVES BY AN ISOTOPE DILUTION METHOD

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## SUMMARY

The successful development of an isotope dilution technique for measuring the milk consumption of suckling beef calves is described. Basically the technique measures the milk consumption of calves following a 6-hour separation period by measuring the ratio of two isotopes, one administered as a known quantity to the calf and the other obtained by the calf suckling an unknown quantity of milk of known radioactivity. The results obtained with the method are discussed in relation to the milk yield of beef cows measured by the oxytocin method.

## INTRODUCTION

Measurement of the milk production of beef cows is desirable, not only as a basis for developing relationships between the rate of growth of calves and their milk consumption, but as a sensitive monitor of the influence of nutritional levels on beef cow performance and also to permit studies of the influence of calf type on cow milk production.

A number of techniques for measuring milk production in beef cows have been developed. The simplest of these measures milk consumption of the calves by weighing them before and after suckling, and is commonly referred to as the Plunket method. The lactation performance of young beef cows under New Zealand conditions using the Plunket method has been presented by Walker and Pos (1963). The Plunket method suffers from the major disadvantage of having to determine a small increase in liveweight, due to milk consumption, in a relatively large animal. Furthermore, extreme care is required to avoid cross-suckling or urination and defecation between suckling and weighing.

To overcome these problems, the oxytocin technique, developed initially by McCance (1959) for use in sheep, has been adapted for use in beef cows (Lamond *et al.*, 1969). Milk production of the cow is measured by total evacuation of the udder with oxytocin (10 to 20 i.u.) before and after a 6-hour separation period of the cow and calf. The chief criticism of the oxytocin method is the possibility that massive doses of oxytocin may influence the subsequent rate of milk secretion (Sprain *et al.*, 1954; Donker *et al.*, 1954).

Recently, an attempt has been made to measure calf milk consumption over longer periods of time using body water dilution techniques (Yates *et al.*, 1971). However, water intake from pasture consumption was not considered in this work.

In an effort to eliminate the errors inherent in the normal Plunket method and to avoid the possibilities of biased results using oxytocin, an isotope dilution technique was evolved. Basically the technique is a sophistication of the Plunket method and estimates calf milk consumption following a 6-hour separation period. By measuring the ratio of two isotopes in the calf's blood, one administered as a known quantity to the calf and the other obtained by the calf suckling an unknown quantity of milk of known radioactivity per ml, milk intake may be calculated. Two isotopes of iodine,  $^{131}\text{I}$  and  $^{125}\text{I}$  were given as sodium iodide since iodide is secreted in milk and readily absorbed from the gut (Miller and Swanson, 1963).

## METHODS

### ISOTOPE METHOD

The following sequential operations form the isotope method:

- (1) The animals were removed from pasture and cows and calves separated for 2 hours.
- (2) Twenty ml of milk was removed from each cow and the calf allowed to suckle (to empty the udder).
- (3) The calf was then removed and each cow received an intravenous (mammary vein) injection of 1 mc  $^{131}\text{I}$  as iodide in sterile water.
- (4) Cows and calves were isolated for 6 hours with cows having access to pasture and water. This period allowed the build up of the products of 6 hours' milk secretion and equilibrated the milk with  $^{131}\text{I}$  iodide.
- (5) The milk sample taken in (2) was incubated for 6 hours at 37°C (to simulate the conditions applying to the  $^{131}\text{I}$ ) with 1  $\mu\text{c}$   $^{125}\text{I}$  per 5 kg calf body weight.
- (6) After the 6 hours, but before suckling, the cow's milk was sampled (3 ml) for  $^{131}\text{I}$  per ml and then the  $^{125}\text{I}$  milk sample incubated as in (4) was forced up the teat canal. (This method of administering the standard  $^{125}\text{I}$  dose was chosen so that the entry of the  $^{125}\text{I}$  and  $^{131}\text{I}$  to the body of the calf would be identical, *e.g.*, via the oesophageal groove into the abomasum.)

- (7) Suckling was permitted immediately following (6) and cows and calves again separated.
- (8) Finally, blood samples from the jugular vein of the calf were taken 1 and 4 hours after suckling, for measurement of the  $^{125}\text{I}/^{131}\text{I}$  ratio.
- (9) Six-hour milk consumption was then calculated from the formula

$$\text{6-hour milk yield (1)} = \frac{\text{Total } ^{125}\text{I administered}}{^{131}\text{I in 1 litre milk}} \times \frac{^{131}\text{I in calf blood}}{^{125}\text{I}}$$

The radioactivity of all samples was counted in a 2-channel autogamma scintillation counter, with suitable corrections being made for background and isotope decay.

## ANIMALS

Two- and three-year-old Angus and Angus cross cows single suckling calves aged 2 to 5 months old, sired by either an Angus or Friesian bull, were used in all cases except in Experiment 4 where Friesian calves aged 2 to 6 weeks of age were used.

## RESULTS

A number of tests were carried out to establish the validity of the technique. These were as follows:

### RECOVERY OF $^{125}\text{I}$ (Experiment 1)

To establish that the calf obtained the entire  $^{125}\text{I}$  dose following injection into the teat canal, the total milk available on oxytocin\* injection (12 i.u.) was collected after the injection of  $^{125}\text{I}$  labelled milk up the teat canal. The percentage recovery in 5 cows ranged from 84.0 to 96.7% with a mean of 92.2%. This was considered a satisfactory recovery rate.

### CONSTANCY OF THE PLASMA $^{125}\text{I}/^{131}\text{I}$ RATIO IN CALVES (Experiment 2)

Blood samples were taken from 5 calves at 30, 60, 90, 120, 150, 320 minutes after suckling and the ratio of  $^{125}\text{I}:^{131}\text{I}$  in the plasma calculated. The values for the 5 calves are given in Table 1.

The ratio was considered to be relatively constant so for further work the average of 1-hour and 4-hour samples was used.

\*Pitocin, Parke Davis.

TABLE 1: RATIO OF  $^{125}\text{I}$ :  $^{131}\text{I}$  IN PLASMA OF CALVES

Calf	Time after Suckling (min)						Average
	30	60	90	120	150	320	
9	7.73	7.45	6.96	6.72	5.72	5.60	6.69
8	7.23	7.16	6.24	6.15	6.67	6.68	6.69
11	2.76	3.80	3.11	2.86	3.19	2.94	2.98
14	3.91	3.67	3.52	3.59	3.79	3.43	3.65
26	4.75	4.68	4.24	4.20	4.34	5.04	4.54
Av.	5.27	5.19	4.81	4.70	4.74	4.74	4.90

CONSTANCY OF THE  $^{131}\text{I}$  CONTENT OF MILK (Experiment 3)

A milk sample for  $^{131}\text{I}$  determination was taken in 3 cows before suckling (initial) and at the conclusion of the suckling period (final). There were only small differences in the 6-hour milk production calculated on either milk sample (Table 2).

TABLE 2: 6 hr MILK YIELD CALCULATED FROM INITIAL AND FINAL MILK SAMPLE

Cow	Initial Milk Sample (l)	Final Milk Sample (l)
1/9	1.72	1.99
2/8	3.72	3.94
14/9	1.89	1.99

## STANDARD QUANTITY OF MILK (Experiment 4)

Seven Friesian calves were fed (suckled) known volumes of  $^{131}\text{I}$ -labelled milk and a known dose of  $^{125}\text{I}$ . Their milk intakes were calculated from the  $^{131}\text{I}/^{125}\text{I}$  ratios calculated on the 1- and 4-hour blood samples. Results are given in Table 3.

TABLE 3: VALUES OF ACTUAL MILK FED AND MILK INTAKE CALCULATED BY THE ISOTOPE TECHNIQUE

	Calf							
	1	2	3	4	5	6	8	
Milk-fed (l)	0.50	1.00	1.00	1.50	2.00	2.00	2.50	
Calculated intake (l)	0.51	0.98	1.02	1.38*	1.79*	2.08	2.50*	

\*Background  $^{125}\text{I}$  counts not known individually for these 3 calves.

### COMPARISON OF ISOTOPE DILUTION METHOD WITH OXYTOCIN METHOD (Experiment 5)

The lactation of all 14 cows used in this experiment was being monitored by the oxytocin technique (6-hour milk yield) every 3 to 4 weeks. A comparison of the 6-hour milk yields obtained by the isotope method and the average of the oxytocin yields measured before and after the isotope method, the daily gain of the calves over the period and their 95-day live-weight are given in Table 4.

TABLE 4: 6 hr MILK YIELD BY OXYTOCIN AND ISOTOPE METHODS

Cow	6-hour Milk Yield (l)		Difference (I - O)		Calf Liveweight Gain (kg/day)	Calf 95-day Weight (kg)
	Oxytocin (O)	Isotope (I)	l	%O		
2/8	2.55	3.83	+1.28	+50.2	1.18	146
5/8	2.26	2.35	+0.09	+ 4.0	1.12	125
34/8	2.11	2.82	+0.71	+33.6	0.91	137
1/9	1.94	1.85	-0.09	- 4.6	0.89	103
18/9	1.92	1.64	-0.28	-15.4	1.01	110
9/8	1.82	1.33	-0.49	-26.9	1.17	115
20/8	1.48	1.52	+0.04	+ 2.7	0.92	97
25/8	1.46	1.24	-0.22	-15.1	1.05	100
11/9	1.46	0.93	-0.53	-36.3	1.03	98
26/8	1.45	1.46	+0.01	+ 0.7	1.05	132
13/8	1.42	1.42	0.00	0.0	0.85	98
7/9	1.19	1.72	+0.53	+44.5	0.96	94
14/9	1.04	1.94	+0.90	+86.5	1.05	99
32/8	1.02	0.82	-0.20	-19.6	0.92	94
Av.	1.65	1.77	+0.12	+ 7.4	1.01	110

The simple correlation coefficient between the 6-hour milk yield by the two methods, calf daily liveweight gain over the experimental period and 95-day body weight are given in Table 5.

TABLE 5: CORRELATION COEFFICIENTS BETWEEN VARIABLES

	Oxytocin Yield (l)	Liveweight Gain (kg/day)	95-day Weight (kg)
Isotope yield (l)	+0.756*	+0.327	+0.770*
Oxytocin yield (l)	—	+0.391	+0.774*

\* $P < 0.01$ .

## DISCUSSION

## THE VALIDITY OF THE TECHNIQUE

Confidence in the validity of the technique in measuring calf milk intake is assured by the results obtained in the consistency of the isotope ratio (Experiment 2), the recovery rates of  $^{125}\text{I}$  (Experiment 1) and, in particular, by the agreement between the "estimated" milk intake with the "actual" milk fed (Experiment 4). The main advantage of this technique over the normal Plunket method is that it avoids weighing the calves which involves numerous inaccuracies. Furthermore, there is no need to separate calves for periods longer than 6 hours to allow sufficient milk build-up to produce a realistic increase in weight post-suckling. The present technique is more demanding than the Plunket technique in equipment and facilities.

## ISOTOPE VERSUS OXYTOCIN METHODS

Large positive and negative differences are obvious in the estimates of milk production/consumption by the two methods (see Table 4). The problem as to which method gives the more realistic figure is difficult to substantiate in the present work.

However, since cow milk production was being monitored at three- to four-weekly intervals over the whole of lactation by the oxytocin method, it is possible to compare the most divergent values with the overall lactation performance (Fig. 1). In these cases the isotope method has produced values very different from those expected from the lactation curve derived from the progressive oxytocin measurements.

In any Plunket-type method, the calf is relied upon to empty the udder to the same degree both before and after the period of separation. One explanation of the results obtained in this work is that such a reliance is misplaced and that the value of the Plunket method, certainly in early/mid-pregnancy, for work which requires more than group averages, may be questionable.

## INFLUENCE OF OXYTOCIN ON MILK SECRETION RATE

A considerable volume of the literature indicating an increase in milk secretion rate following oxytocin injections has been confused in that frequency of milking has also increased (Smith, 1947; Lakshmanan *et al.*, 1958; Linzell, 1967; Linzell and Peaker, 1971). Of the work where there has been no change in the frequency of milking when oxytocin has been administered, that of Sprain *et al.* (1954), who alternated 14-day

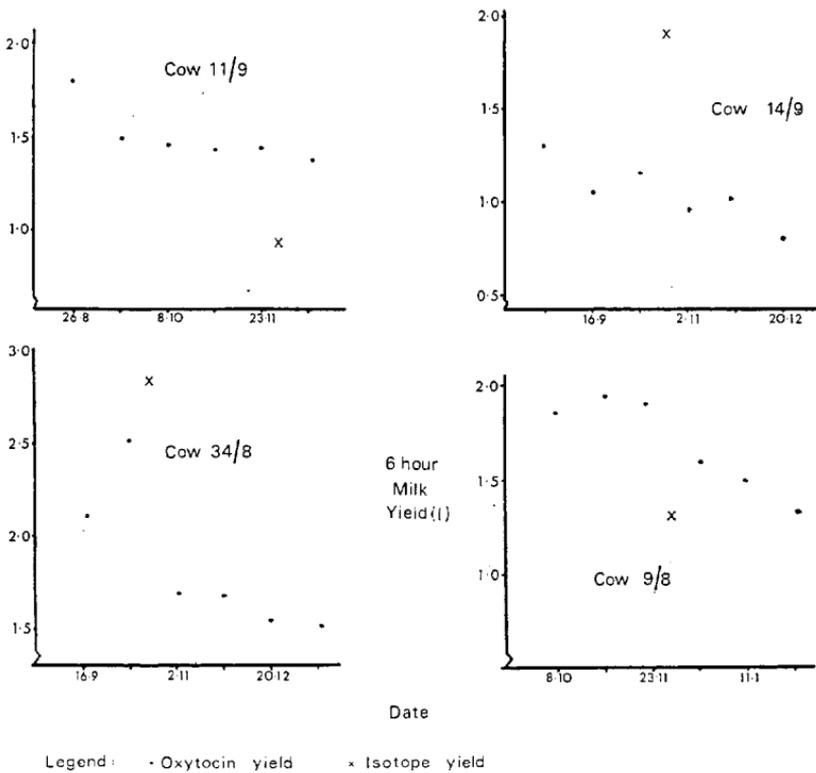


FIG. 1

periods of no oxytocin or 10 i.u. oxytocin prior to each milking throughout lactation, showed a 9% increase in milk production during the oxytocin treatment. However, neither Shaw (1942) over an 8-day experimental period of 10 i.u. prior to milking, or Weelock *et al.* (1965) with a 48-hour experimental period of 6-hour milkings with 20 i.u. oxytocin could detect any change in milk production.

If the inconsistent emptying of the udder by the calves discussed above is a random effect, as it would appear to be, then any galactopoetic effect of oxytocin would appear as a regular increase in 6-hour milk yield. The lack of any consistent difference between 6-hour milk production measured by the oxytocin and isotope methods in individual cases, and the good agreement between the two methods on a group basis in this work, supports the conclusions of Shaw (1942) and Weelock *et al.* (1965) that it is unlikely that oxytocin, given under the present regime, significantly influences milk secretion rate.

However, if the effect of oxytocin on milk secretion rate varies between cows because of their different endocrine, genetic and physical characteristics, then the above suggestion, that any oxytocin stimulation would be a consistent effect, would not be valid. The good agreement between the average milk yield by the two methods would then be purely coincidental.

The only way to determine if oxytocin is having a real effect on milk secretion rate in these cows would be to obtain 6-hour milk yields with and without oxytocin. Unfortunately, it was not possible to obtain satisfactory let-down, even in trained cows, without exogenous oxytocin.

Further development of the isotope technique to measure milk intake over a continuous period of 3 to 4 days may overcome the apparent unequal emptying of the udder and then be of value in determining the nature of any oxytocin effect.

#### CONCLUSIONS

The isotope technique accurately measures the intake of a suckling calf, and, as such, is an alternative technique to the Plunket method. The 6-hour milk yields obtained by the isotope method, while showing good agreement on a group basis, do not agree in all individual cases with the 6-hour milk yield obtained by the oxytocin method. While it was not possible to determine the reason for these discrepancies from this work, it is felt that the most likely explanation is the inconsistent emptying of the udder by the suckling calf.

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