EVALUATION OF TECHNIQUES FOR ESTIMATING MILK PRODUCTION BY SOWS
2. ESTIMATING THE MILK CONSUMPTION OF PIGLETS BY THE DEUTERIUM OXIDE DILUTION AND WEIGH-SUCKLE-WEIGH METHODS

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Summary

An experiment was conducted to compare the traditional weigh-suckle-weigh method and the D_2O dilution technique to estimate milk consumption of suckling piglets. Milk consumption of 50 individual piglets was estimated on four consecutive days by the D_2O dilution method and for approximately 8 hours on both the second and fourth day by the traditional WSW method. The average milk intake of piglets estimated by the D_2O dilution method was 45.0 g/hr and there were no significant differences between the four measurement period. The traditional weigh-suckle-weigh method provided a significantly lower estimate of milk consumption (36.8 g/hr). However correction for weight losses associated with milk suckling and weighing would increase the weigh-suckle-weigh estimate to a level similar to that determined by the D_2O dilution method.
(Key Words: Milk Consumption, Piglets, Deuterium Oxide Dilution, Weigh-Suckle-Weigh)

Introduction

The weigh-suckle-weigh (WSW) technique, which involves weighing piglets immediately before and after suckling for about 6 to 9 consecutive nursing bouts is the traditional method of estimating milk yield of sows (Hartman et al., 1962). In this method the suckling interval between nursings of 60 minutes is usually imposed (Speer and Cox, 1984) to approximate the natural suckling interval. This standard suckling interval, which is often imposed, together with the possibility that the WSW technique disrupts the maternal-offspring relationship during the measurement period, may affect the amount of milk secreted by the sow (Pettigrew et al., 1985). The WSW method is also labour intensive, time consuming and may also be inaccurate because of piglet weight losses due to defaecation, urination (Van Spaendonck and Vanschoubroek, 1964; Yang et al., 1980) and metabolism (Klaver et al., 1981). Use of the D_2O dilution method has significant advantages over the WSW technique for estimating milk consumption. During the measurement period the piglets were left undisturbed and were allowed to suckle when they chose. The D_2O dilution method was shown to be an accurate and precise method of estimating milk consumption in the previous paper (Prawirodigdo et al., 1990). The aim of this experiment was to compare the WSW method with the D_2O dilution technique to estimate milk consumption of piglets.

Materials and Methods

Animals

Six lactating sows, each suckling 7-11 piglets were used in this study to determine the milk consumption of piglets using the D_2O dilution and the WSW techniques.

Design and management

Sows and their offspring were housed in farrowing crates in an insulated room. Supplementary heat for the litter was provided by an infra-red lamp in covered forwards creeps.

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Piglets had free access to their dams except during each measurement period when they were only allowed access to the sow every hour to suckling. To reduce any possible disruptive effect of piglet removal from the sow on milk yield, a wire mesh barrier was used to separate piglets from the sow during the WSW measurement period. Sows were offered 5 kg of a lactating sow diet and were fed 3 times each day. Milk consumption of piglets was estimated during the second or third week of lactation.

After the first nursing after 07.00 h, piglets were separated from their dams for 45 minutes (first fasting) to standardizise gut fill. The piglets were individually identified and weighed in an individually marked plastic bin. An electronic scale (Sartorius 3902MP8) with a readability of 0.1 g was used and programmed to provide a stable reading which was a mean of 20 readings obtained over a 5-second period. Each piglets was injected intra muscularly with the appropriate amount of D_2O (approximately 1.75 g/kg Lwt). After a 2-hr fast to allow the D_2O to equilibrate with total body water a blood sample was taken from each piglet. The piglets were then returned to the sows for the measurement period of approximately 21-22 hr after which piglet were fasted for 45 minutes after a suckling and a second blood sample was taken.

The first WSW measurement period began 15 minutes later. During the subsequent eight hours piglets were weighed before and after suckling each hour to determine individual mean weight gains of piglets at each suckle. A blood sample was taken 45 minutes after the eighth of suckle at the end of the WSW measurement period. Piglets were returned to the sow for the subsequent 37-39 hr. At the end of this period another blood sample was taken 45 minutes after a suckle and the second WSW measurement period began 15 minutes later. Finally, at the end of the second WSW measurement period a blood sample was taken, there was a second injection of D_2O (0.8 g/kg Lwt), a 2-h fast for equlibration and a final blood sample. This was done to estimate the size of body water pool at the end of the second WSW measurement period. The size of body water pool at intermediate times was determined by interpolation. The outline of the procedure to determine by interpolation. The outline of the procedure to determine milk intake by the D_2O dilution and WSW method is shown in figure 1.

Milk samples were collected from four sectors of the udder while the piglets were being fasted at the end of the final measurement period during the equilibration period of the second injection of D_2O. Milk samples were analysed for dry matter, crude protein and gross energy contents.

Suckle
Separate (fast) 45 minutes
First injection of D_2O (1.75 g/kg L.W.)
Fast 2 hours

First blood sample
Measurement period (21-22 hr)
Separate (fast) 45 minutes
Second blood sample

First WSW measurement period (8 hrs)
Separate (fast) 45 minutes

Third blood sample
Measurement period (37-39 hrs)
Separate (fast) 45 minutes
Fourth blood sample

Second WSW measurement period (8 hrs)
Separate (fast) 45 minutes

Fifth blood sample
Second injection of D_2O (0.8 g/kg L.W.)
Fast 2 hours

Sixth blood sample

Figure 1. Procedure of the D_2O dilution and the WSW methods to determine milk intake by piglets.

Statistical analysis

The milk consumption data were analysed by analysis of variance and the significance of differences between two the methods of estimating milk consumption were examined by least significant difference (Steel and Torrie, 1981).

Results

The mean milk intake of piglets estimated by the D_2O dilution method were 17.7% and 18.5% greater than milk consumption determined by the WSW method when these two techniques were practiced simultaneously during the measurement periods of day 2 and day 4 respectively (table 1).

TABLE 1. COMPARISON OF MILK INTAKE ESTIMATED BY THE D_2O DILUTION METHOD AND INTAKE ESTIMATED BY THE WSW METHOD

Measurement period	Mean length of measurement period (hr)	Total number of piglets	Estimated milk intake per piglet		
			Mean (g/hr)	Range (g/hr)	S.E.M
Day 1					
D_2O dilution	21	50	44.6[a*]	12.1 to 82.0	2.2
WSW	–	–	–	–	–
Day 2					
D_2O dilution	8.3	50	44.8[a]	13.0 to 89.0	2.1
WSW	8.3	50	36.9[b]	12.8 to 60.6	1.6
Day 3					
D_2O dilution	39.0	50	45.5[a]	23.7 to 74.0	1.9
WSW	–	–	–	–	–
Day 4					
D_2O dilution	7.7	50	44.9[a]	12.2 to 79.9	2.1
WSW	7.7	50	36.6[b]	4.5 to 52.3	1.3
		S.E.M.	169		

*a and b differ significantly ($p < 0.01$).
S.E.M. (Standard error of the mean) is shown at the base of the column.

Furthermore there were no significant differences between the four measurement periods, in milk intake estimated by the D_2O dilution method despite the WSW method being imposed during the second and fourth measurement periods (table 1).

Within litters, mean milk intake of individual piglets were significantly different ($p < 0.05$) and were significantly correlated to their corresponding growth rate over the four measurement periods (table 2). When piglet performance data from all sows were combined, the relationship between average milk intake (M; g/hr) and growth rate (GR; g/d) over the corresponding period was also highly significant; the respective regression equation being $GR = 4.64\ M - 0.1$; $R^2 = 0.68$; $p < 0.001$. The average daily milk yield of sows ranged from 6.9 to 12.3 kg and appeared to be related to litter size (table 3).

Discussion

Mean hourly milk consumption by piglets estimated by the WSW technique was 8.2 g (18.1%) less than that estimated by the D_2O dilution method. Both Rudolph et al. (1984) and Pettigrew et al. (1985) also observed that milk consumption determined by the WSW technique was less than that estimated by the D_2O dilution method. Rudolph et al. (1984) reported that the milk intake of suckling piglets was 39.6 vs 29.7 g/hr when estimated by the D_2O dilution and WSW methods respectively. Pettigrew et al. (1985) found that the difference between the two method was only 3.5 g/hr; Milk intake was 33.2 and 29.7 g by the D_2O and WSW methods respectively (Pettigrew et al. 1985).

Although the observation by Pettigrew et al. (1985) that the WSW method underestimated milk intake is similar to that reported in this experiment, the reason are quite different. In a similar design to the experiment reported here, Pettigrew et al. (1985) also determined milk intake by both methods simultaneously and found that the two methods revealed similar milk intakes which were lower than the estimate derived by the D_2O method either before or after WSW period. This led Pettigrew et al. (1985) to the conclusion

TABLE 2. CORELATION WITHIN LITTERS BETWEEN THE GROWTH RATES OF INDIVIDUAL PIGLETS AND THEIR MILK INTAKES AS ESTIMATED BY THE D_2O DILUTION METHOD OVER THE FOUR MEASUREMENT PERIODS

Sow no.	Initial weight of piglet (kg)	Weight gain of piglet (g/day)	Average milk intake determined by the D_2O dilution method (weighted mean) (g/hr)	Coefficient of determination within litters (R^2)
32	3.122	135.7	34.9	0.91
	3.853	170.3	37.3	
	3.995	191.3	41.3	
	4.269	189.3	44.7	
	4.159	229.0	45.5	
	4.483	259.7	49.8	
	4.286	230.7	50.8	
	4.668	260.0	50.8	
	4.474	255.3	53.3	
	4.418	270.3	57.3	
	4.187	281.0	58.3	
41	2.981	172.7	26.7	0.65
	2.981	114.0	32.1	
	2.763	185.7	32.3	
	2.790	205.3	32.4	
	3.740	187.7	35.5	
	4.289	234.0	44.2	
	4.562	234.3	47.2	
	4.330	292.3	48.5	
44	5.382	84.7	38.9	0.86
	6.506	236.0	48.4	
	6.319	256.3	53.1	
	6.581	275.7	57.1	
	4.411	252.3	58.9	
	6.604	270.7	62.0	
	6.809	323.3	63.5	
45	2.592	126.7	26.7	0.96
	3.292	151.3	34.2	
	3.319	155.1	36.8	
	3.028	191.1	40.6	
	4.030	191.1	42.9	
	3.079	192.7	44.8	
	4.562	207.1	46.3	
	4.205	215.1	50.0	
49	2.150	146.3	29.6	0.85
	2.687	224.2	39.7	
	3.848	182.8	40.6	
	2.894	265.6	46.9	
	3.919	241.7	47.0	
	3.759	255.4	55.0	
	4.837	299.6	60.0	

TABLE 2. (CONTINUED)

Sow No.	Initial weight of piglet (kg)	Weight gain of piglet (g/day)	Average milk intake determined by the D_2O dilution method (weighted mean) (g/hr)	Coefficient of determination within litters (R^2)
58	4.586	143.0	36.9	0.89
	4.635	135.7	37.8	
	4.638	165.7	42.0	
	5.051	144.3	43.6	
	5.042	195.3	45.7	
	5.548	196.0	50.6	
	5.079	229.7	52.5	
	6.208	214.3	52.8	
	6.191	230.3	55.9	

TABLE 3. MILK YIELD OF SOWS ESTIMTED BY THE D_2O DILUTION METHOD

Sows no.	Litter size	Age of piglets on first day of measurement period (days)	Average sow milk yield (kg/day)
44	7	19	9.17
49	7	13	7.65
41	8	15	7.17
45	8	17	7.74
58	9	21	10.03
32	11	14	12.58

that disruption caused by the WSW method may have reduced milk consumption. In contrast, the results of the present experiment show that the WSW method did not affect milk intake by piglets because D_2O dilution estimates were similar for all periods. Any possible disruption during the WSW period was minimized in this experiment by quickly and quietly weighing the piglets and maintaining visual contact between the sow and her litter between the suckling bouts.

The difference between milk intake estimated by the two methods in the present experiment was probably due to the failure to take into account the possible metabolic and salivary losses associated with suckling during the WSW measurement period. Various estimates for the weight loss of individual piglets due to metabolism and saliva tion have been reported. For example, piglets of 4.0 kg body weight which are weighed on two occasions seven minutes apart, lost approximately 8.3 g according to Klaver et al. (1981) and 4.2 g as reported by Noblet and Etienne (1986). Correction for these weight losses associated with suckling and weighing would increase the WSW estimates in the present experiment to a similar level to that determined by the D_2O dilution method.

The significant correlation coefficient of growth rate during the experimental period and milk intake of the piglets, both between litter, and within litter indicated that growth rate was dependent upon the milk intake of piglets. In a comprehensive study to investigate the relationship between piglet milk intake and piglet weight gain, Lewis et al. (1978) found that only 34% of the variation in piglet gain could be attributed to variation in milk intake. In the present study 68% of the variation in piglet gain was attributed to variation in milk intake. The closer relationship between piglet gain and milk intake in the present experiment indicates that genetic and environmental factors (Hemsworth et al., 1976) may have been more important in determining piglet growth rate in the study of Lewis et al., (1978). Furthermore, Lewis et al. (1978) used WSW method, which may have yielded a less accurate estimate of milk intake.

The results of this experiment show that, provided there is minimal disruption to normal suckling behaviour, and weight losses associated with suckling and weighing are taken into account,

the WSW method may accurate estimate milk intake.

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