January 1962

PARAMETERS FOR MILK YIELD AND FOR PERCENTS OF ASH, DRY MATTER, FAT AND PROTEIN IN SOWS

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W. G. Pond, L. D. Van Vleck and D. A. Haetman. 1962. Parameters for Milk Yield and for Percents of Ash, Dry Matter, Fat and Protein in Sows. *Journal of Animal Science* 21:293-297

Abstract: Milk was collected separately by machine from four to six glands on nine Yorkshire and Berkshire sows 2 or 3 days after farrowing and at weekly intervals throughout 6 weeks of lactation. Milk yield was measured following intramuscular injection of oxytocin, and the percent of ash, dry matter, fat and protein in the milk from each gland was determined. The average milk yield per gland, following a 1-hour period during which the pigs had been removed from the sow reached a peak of 74.6 gm. 3 weeks after farrowing. The ash content was 0.79% 2 or 3 days after farrowing, declined to 0.71% 1 week after farrowing and gradually increased to 0.96% 6 weeks after farrowing. The average dry matter content was 21.36% 2 or 3 days after farrowing, then declined to 19.52% 2 weeks after farrowing and increased to 20.55% at 6 weeks. The average fat content steadily declined from 7.83% 2 or 3 days after farrowing to 6.07% at 6 weeks. The average protein content was 5.97% at 2 or 3 days after farrowing, then declined to 5.26% at 2 weeks and gradually increased to 5.82% at 6 weeks. A highly significant difference ($P < .01$) among glands within sows was noted in fat content. No statistically significant differences were found in milk yield or in percents of ash, dry matter or protein within sows. Highly significant differences ($P<.01$) were found among sows in milk yield 2 or 3 days after farrowing and at each weekly interval thereafter. Highly significant differences among sows ($P<.01$) were noted in ash content 2 or 3 days and 1, 2, 3 and 6 weeks after farrowing, in dry matter content 2 or 3 days and 1, 2 and 3 weeks after farrowing, in fat content 1, 2, 3, 5 and 6 weeks after farrowing and in protein content, 1, 2, 3 and 6 weeks after farrowing. Significant differences among sows ($P<.05$) were also noted for dry matter content at 4 weeks and for fat and protein content at 5 weeks after farrowing. The data on within sow variation indicate that representative samples for ash, dry matter or protein content but not for fat can be obtained from a single gland.

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MILK production in swine has been studied from the standpoint of both total yield and composition. Experimental data and literature reviews have been recently presented for yield (Allen and Lasley, 1960) and composition (Neuhaus, 1961; Jylling and Sorensen, 1960) of sow's milk. Most reports have not been concerned directly with variations to be expected in yield and composition among glands within a given sow or among sows.

The work to be reported was designed to study variation among individual glands and among sows in milk yield and in protein, fat, ash and dry matter content of the milk over a 6-week lactation.

Experimental Procedure

Nine Berkshire and Yorkshire sows were used to collect data on milk yield and composition during the first 6 weeks of lactation. Milk samples were obtained by machine (Hartman and Pond, 1960) from four to six glands on each sow 2 or 3 days after farrowing and at weekly intervals thereafter for 6 weeks. Milk ejection was accomplished by intramuscular injection of 4–5 ml. of oxytocin 10–20 sec. before machine milking. Milking was continued until milk ceased to flow, usually about 5 min. Pigs were removed from the sow approximately 1 hour prior to milking and were returned immediately after milking. No attempt was made to ascertain the exact time interval between nursing and machine milking. All litters were standardized to six pigs 1 week after farrowing.

The amount of milk, in grams, obtained from each gland at each milking was recorded and samples were saved for ash, dry matter, fat and protein determination. Five gm. samples of milk were frozen and then dried for 24 hours under a vacuum of 28 in. of Hg at room temperature [3] for gravimetric determination of dry matter. Dried samples were ashed at 600° C., after weighing, to determine ash content. Fresh milk samples were used for fat determination by the Babcock method and for protein determination by the Orange G Dye method (Udy, 1956; Ashworth *et al.*, 1960).

Results and Discussion

The mean values for grams of milk and for percent of ash, dry matter, fat and protein in the milk obtained 2–3 days after farrowing and at weekly intervals for 6 weeks are given in table 1.

The largest average milk yield from individual glands following intramuscular oxytocin injection of the sow was obtained at 3 weeks after farrowing (74.6 gm.) and the second largest at 4 weeks after farrowing (59.0 gm.). This is in agreement with other reports to the effect that the peak of lactation in sows occurs between the third and fifth week (Hughes and Hart, 1935; Smith, 1952, 1959; Lodge 1959a; Allen and Lasley, 1960; Hartman and Pond, 1960). Allen and Lasley (1960) observed breed differences in the time at which the peak was reached.

The average dry matter content declined from 21.4% 2 or 3 days after farrowing to a low of 19.5% 2 weeks after farrowing followed by a gradual rise to 20.6% 6 weeks after farrowing. Bowland *et al.* (1949a) and Perrin (1955) reported a large reduction in dry matter content during the transition from colostrum to milk. The overall average of 20.2% dry matter compares favorably with other reports (Braude *et al.*, 1947; Bowland *et al.*, 1949a; Heidebrecht *et al.*, 1951; Perrin, 1954; Lodge, 1959 a, b; Jylling and Sorensen, 1960).

The average ash content declined from 0.79% 2 or 3 days after farrowing to 0.71% 1 week after farrowing and then increased gradually to 0.96% after 6 weeks. This agrees with the observation of Jylling and Sorsensen (1960), but is somewhat contrary to the results of Perrin (1955) who observed a gradual

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TABLE 1. MILK YIELD AND PERCENT OF ASH, DRY MATTER, FAT AND PROTEIN IN SOW MILK AT INTERVALS THROUGH SIX WEEKS LACTATION

Item	Time after farrowing						
		Weeks					
	2 or 3 days	1	2	3	4	5	6
Av. milk yield, gm.[a]	32.4	49.3	48.1	74.6	59.0	43.2	52.7
No. of samples [b]	53	56	50	50	51	45	37
Av. ash content, %	0.79	0.71	0.72	0.77	0.83	0.90	0.96
No. of samples [b]	47	55	46	49	49	43	34
Av. dry matter content, %	21.36	19.59	19.52	19.94	19.89	20.67	20.55
No. of samples [b]	46	55	49	48	48	42	37
Av. fat content, %	7.83	7.77	7.63	7.55	7.20	6.81	6.07
No. of samples [b]	45	48	45	47	46	36	30
Av. protein content, %	5.97	5.36	5.26	5.49	5.63	5.75	5.82
No. of samples [b]	49	55	46	49	50	43	35

[a] Amount of milk obtained from one gland following oxytocin injection 1 hour after removal of pigs from sow.
[b] Each sample represents a single collection from one gland. Nine sows are represented except at week-6, where eight sows are represented. Four to six glands per sow were milked except at week-1, where seven glands were milked on each of two sows and six on the remainder. Where the number of samples representing the ash, dry matter, fat or protein determination is less than that representing the milk yield the deficit is due to an insufficient amount available for analysis.

increase in ash content from parturition through the lactation period. The overall average of 0.80% obtained in the present study is somewhat lower than, but in general agreement with, published values (Braude *et al.*, 1947; Bowland, *et al.*, 1949a; Heidebrecht *et al.*, 1951; Perrin, 1954, 1955; Lodge, 1959a; Salmon-Legagneur, 1959; Jylling and Sorensen, 1960).

The average fat content declined steadily throughout lactation from 7.83% 2 or 3 days after farrowing to 6.07% six weeks after farrowing. This is in agreement with some reports (Braude *et al.*, 1947; Bowland *et al.*, 1949a, 1949b; Heidebrecht *et al.*, 1951; Smith, 1952, 1959; Barber *et al.*, 1955) but contrary to those of others (Hughes and Hart, 1935; Willett and Maruyama, 1946).

The average protein content did not change appreciably during the period of lactation measured although there was a slight reduction from 2 or 3 days after farrowing (5.97%) to the second week (5.26%), followed by a gradual increase to 5.82% at the sixth week. This agrees with other reports (Perrin, 1955; Smith, 1959; Jylling and Sorensen, 1960). The extremely high percent of protein generally associated with colostrum during the first few hours after farrowing was not observed 2 or 3 days after farrowing in the present study. The overall average protein content of 5.60% agrees favorably with other reported values (Braude *et al.*, 1947; Bowland *et al.*, 1949a; Heidebrecht *et al.*, 1951; Smith, 1952 1959; Perrin, 1954, 1955; Lodge, 1959b; Salmon-Legagneur, 1959; Jylling and Sorensen, 1960).

The among glands within sows analyses of variance for milk yield and for percent of ash, dry matter, fat and protein in the milk are given in table 2.

The statistical model used for testing the difference among glands within sows is:

$$y_{ijk}=\mu+s_i+g_{ij}+b_1x_{ijk}+b_2\sqrt{X_{ijk}}+e_{ijk}$$

where y_{ijk} is the observation on the k^{th} week of the j^{th} gland within the i^{th} sow, μ is an effect common to all observations, s_i is the fixed effect due to the i^{th} sow, g_{ij} is the fixed effect due to the j^{th} gland within the i^{th} sow, e_{ijk} is a random effect specific to the ijk^{th} observation, b_1 and b_2 are the within gland regression coefficients associated with X_{ijk} (the week number associated with the ijk^{th} observation) and $\sqrt{X_{ijk}}$, respectively. The mean square for glands within sows was adjusted for both regressions and tested against the residual mean square also adjusted for both regressions. The b values can be used to plot approximate lactation curves for the various components. There was no significant difference among glands within sows in grams of milk, or in the percent of ash, dry matter or protein produced. However, a highly significant difference ($P<.01$) among glands existed in the percent of fat produced. It has been shown in the cow that the final fraction of a milking contains a higher percent of fat than earlier fractions (Johansson, 1952). However, Jylling and Sorensen (1960) failed to demonstrate a regular variation in fat content between three successive fractions of milk from the same gland in sows. Considerable variation has been noted in the fat content of sow milk from day to day by Perrin (1955) and

TABLE 2. ANALYSIS OF VARIANCE AMONG SOWS AND AMONG GLANDS WITHIN SOWS FOR EACH TRAIT

Source of variation	d.f.	Sum of squares	d.f.	Adj. sum of squares	F
		Milk wt., gm.			
S (Sow)	8	49,275.6	...	.....	
G/S[a] (Glands within sow)	69	95,529.3	...	.....	
R (Residual)	264	294,117.7	262	268,106.8	
R+G/S	333	389,647.0	331	358,383.8	
Adj. G/S	...	...	69	90,277.1	1.3
	b_1[b]=−30.545	b_2[c]=119.963			
		Ash, %			
S	8	0.58	...	...	
G/S	69	1.01	...	...	
R	245	5.10	243	3.11	
R+G/S	314	6.11	312	3.86	
Adj. G/S	...	...	69	0.75	0.9
	b_1[b]=0.222	b_2[c]=−0.675			
		Dry matter, %			
S	8	370.5	...	.....	
G/S	68	477.6	...	.....	
R	248	2,045.4	246	1,940.7	
R+G/S	316	2,522.9	314	2,403.4	
Adj. G/S	...	...	68	462.6	0.9
	b_1[b]=2.415	b_2[c]=−8.724			
		Fat, %			
S	8	95.2	...	....	
G/S	68	167.5	...	....	
R	220	304.7	218	275.7	
R+G/S	288	472.2	286	425.3	
Adj. G/S	...	...	68	149.6	1.7**
	b_1[b]=−0.500	b_2[c]=1.171			
		Protein, %			
S	8	4.6	...	...	
G/S	71	18.4	...	...	
R	247	52.6	245	39.7	
R+G/S	318	71.0	316	54.7	
Adj. G/S	...	...	71	14.9	1.3
	b_1[b]=0.839	b_2[c]=−2.996			

[a] Samples were not always obtained from the same six glands on a given sow; therefore, d.f. are greater than 53[(9x6)−1].
[b] Regression coefficient of trait on week number.
[c] Regression coefficient of trait on $\sqrt{\text{week number}}$.
** ($P<.01$) significant difference.

from week to week by Jylling and Sorensen (1960). The sources of these observed variations in fat content among glands should be studied further.

The statistical model for testing differences among sows is:

$$y_{ij}=\mu+s_i+g_{ij}+e_{ij}$$

Note that the gland within sow effect is completely confounded with the random error effect. This will lower the precision of measuring differences among sows.

A measure of the among sow variation in milk yield, in grams, and in the percent of ash, dry matter, fat and protein contained in the milk for each collection period (day-2 or day-3 after farrowing and weekly for 6 weeks after farrowing) is given in table 3. Highly significant differences ($P<.01$) were found throughout lactation among sows in grams of milk obtained. Smith (1959) and Allen and Lasley (1960) reported genetic differences in milk production in sows. Highly significant differences ($P<.01$) also existed in percent of ash 2 or 3 days and 1, 2, 3 and 6 weeks after farrowing, in dry matter content 2 or 3 days and 1, 2 and 3 weeks after far-

TABLE 3. ANALYSIS OF VARIANCE, AMONG AND WITHIN SOWS BY WEEK AFTER FARROWING

	Time after farrowing						
		Weeks					
	2 or 3 days	1	2	3	4	5	6
				Milk wt., lb.			
R [a]	243.77	609.76	620.10	1148.80	883.27	492.40	407.26
F [b]	8.9**	4.2**	5.3**	3.6**	5.1**	6.5**	20.5**
d.f. for S	8	8	8	8	8	7	6
d.f. for R	44	47	41	41	42	37	30
				Ash, %			
R	0.007	0.004	0.003	0.003	0.011	0.051	0.005
F	6.2**	7.4**	6.5**	4.9**	1.3	1.5	5.0**
d.f. for S	8	8	8	8	8	7	6
d.f. for R	38	46	37	40	40	35	27
				Dry matter, %			
R	6.68	1.32	1.91	0.45	7.59	17.96	15.53
F	4.4**	3.9**	11.3**	15.1**	1.2	2.8*	0.7
d.f. for S	8	8	8	8	8	7	6
d.f. for R	37	46	40	39	39	34	30
				Fat, %			
R	2.67	0.33	0.41	0.28	0.37	0.40	0.68
F	2.0	31.4**	21.1**	13.7**	6.8*	17.4**	16.0**
d.f. for S	8	8	7	8	8	7	5
d.f. for R	36	39	37	38	37	28	24
				Protein, %			
R	0.36	0.01	0.06	0.02	0.13	0.21	0.10
F	2.7	23.0**	3.1**	9.8**	1.7	2.8*	7.2**
d.f. for S	8	8	7	8	8	7	6
d.f. for R	40	46	38	40	41	35	28

** ($P<.01$) among sows.
* ($P<.05$) among sows.
[a] Residual mean square.
[b] Among sow mean square/within sow mean square (R).

rowing, in fat content 1, 2, 3, 5 and 6 weeks after farrowing and in protein content 1, 2, 3 and 6 weeks after farrowing. Significant differences among sows ($P<0.05$) also existed for dry matter four weeks and for fat and protein content 5 weeks after farrowing. Failure to reach statistically significant differences among sows in ash at weeks 4 and 5, dry matter at weeks 4 and 6, fat at day 2 or 3, and protein at day 2 or 3 and week 4 may have been due to the small sample. The overall high level of significance indicates that large individual differences exist among sows in the amounts of all of the components here considered which are secreted into the milk.

While lactose content of the milk was not measured in this study, the amount produced can be taken to be the difference between percent dry matter and the sum of the percent ash, fat and protein. When this is done, using average values for each component, the percent of lactose in the milk appears to decline slightly between two or three days after farrowing and week one after farrowing and then gradually increases throughout lactation. This is contrary to the observation of Lodge (1959b) who reported a negative correlation between percent of protein and lactose in the milk.

Summary

Milk was collected separately by machine from four to six glands on nine Yorkshire and Berkshire sows 2 or 3 days after farrowing and at weekly intervals throughout 6 weeks of lactation. Milk yield was measured following intramuscular injection of oxytocin, and the percent of ash, dry matter, fat and protein in the milk from each gland was determined.

The average milk yield per gland, following a 1-hour period during which the pigs had been removed from the sow reached a peak of 74.6 gm. 3 weeks after farrowing. The ash content was 0.79% 2 or 3 days

after farrowing, declined to 0.71% 1 week after farrowing and gradually increased to 0.96% 6 weeks after farrowing. The average dry matter content was 21.36% 2 or 3 days after farrowing, then declined to 19.52% 2 weeks after farrowing and increased to 20.55% at 6 weeks. The average fat content steadily declined from 7.83% 2 or 3 days after farrowing to 6.07% at 6 weeks. The average protein content was 5.97% at 2 or 3 days after farrowing, then declined to 5.26% at 2 weeks and gradually increased to 5.82% at 6 weeks.

A highly significant difference ($P<.01$) among glands within sows was noted in fat content. No statistically significant differences were found in milk yield or in percents of ash, dry matter or protein within sows.

Highly significant differences ($P<.01$) were found among sows in milk yield 2 or 3 days after farrowing and at each weekly interval thereafter. Highly significant differences among sows ($P<.01$) were noted in ash content 2 or 3 days and 1, 2, 3 and 6 weeks after farrowing, in dry matter content 2 or 3 days and 1, 2 and 3 weeks after farrowing, in fat content 1, 2, 3, 5 and 6 weeks after farrowing and in protein content, 1, 2, 3 and 6 weeks after farrowing. Significant differences among sows ($P<.05$) were also noted for dry matter content at 4 weeks and for fat and protein content at 5 weeks after farrowing.

The data on within sow variation indicate that representative samples for ash, dry matter or protein content but not for fat can be obtained from a single gland.

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