MILKING TECHNIQUES AND THE COMPOSITION OF GUINEA PIG MILK [1]

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TWO FIGURES

(Received for publication February 16, 1951)

Different species of animals have different nutritional needs and digestive abilities. This fact is well illustrated by the wide differences in the composition of the milk of different species (table 1). Each of these milks must be well adapted to the young of its own kind, but in many cases it cannot support growth in the young of another species.

It is believed that a comparative study of the milks of different species may offer clues to differences in nutritional requirements which might otherwise be overlooked. Such information would be of particular value in the case of those species which are commonly used for laboratory experiments in nutrition. This report presents data from an extensive study of the milk of the guinea pig.

EXPERIMENTAL

Milking machine design

Several investigators have described miniature milking machines (Cox and Mueller, '37; Temple and Kon, '37; Glimstedt, Moberg and Widmark, '37; Houston and Kon, '39; Mueller, '39; Kahler, '42). A simplified design which

[1] This study was supported in part by grants from the Robert Gould Foundation, Inc., Cincinnati, Ohio, and the Herman Frasch Foundation, New York City.

retains the desirable features recommended by previous workers is shown in figure 1. This apparatus permits adjustment of the degree of vacuum, the frequency of application, and the relative length of the suction and release periods in each cycle. A Gast Portable, Rotary Air Blast and Suction Apparatus [2] has been used for adjusting the level of vacuum, although a water pump equipped with a suitable vacuum reg-

TABLE 1

The composition of milk — The "most nearly perfect food"

	PORPOISE [1]	RAT [2]	REINDEER [1]	HUMAN [3]	COW [3]	GUINEA PIG
Water (%)	41.1	68.3	65.3	88	87	83.56
Solids (%)	58.9	31.7	34.7	12.4	12.8	16.44
Calories/100 gm	462	191	235	71	69	77
Fat (%)	45.8	14.8	19.7	3.8	3.8	3.92
Lactose (%)	1.31	2.8	2.6	7.0	4.8	3.02
Ash (%)	0.57	1.50	1.43	0.21	0.71	0.82
Protein (%)	11.2	11.8	11.9	1.2	3.3	8.10
Casein (%)		9.2	8.7	0.4	2.8	6.62
Whey protein (%)		1.5	2.2	0.6	0.6	1.48
Reichert Meissl number		4.9	34	0.8	28.8	0.41
Polenske number		11.7	1.1	1.2	1.5	1.47
Iodine number		41	23	61.6	38.4	79.5
Saponification number		231	236	204.7	248.0	196

[1] Values collected from many sources.

[2] Values from: The composition of milk from stock rats and an apparatus for milking small laboratory animals, W. M. Cox and A. J. Mueller, J. Nutrition, *13:* 249–261, 1937.

[3] Values from: The Composition of Milks, Icie G. Macy et al., Natl. Res. Council Bull. 119, 1950.

ulator may be substituted. The motor used to turn the stopcock on the suction flask is equipped with a rheostat to permit variations in the number of pulsations per minute. The stopcock is lubricated with a light vaseline to allow easy rotation. Catheter tubing is used as leads from the teat cups to the small Erlenmeyer flask employed to collect the milk. A variety of teat cups were made by "flaring" the ends of glass tubing varying from 4 to 6 mm in outside diameter.

[2] Arthur H. Thomas Co., Philadelphia.

The flared end shoud be large enough to give a vacuum-tight seal against the surface of the gland without permitting the gland to be sucked into the tubing. The tubing should be large enough to allow room for the expansion of the teat which occurs during milking.

Milking techniques

It has been observed that the level of vacuum (10 to 11 inches of mercury) and the pulsations (25 per minute) for satisfactory milking of guinea pigs agree with the recommendations (20 to 30 cm of mercury and 20 to 30 pulsations per

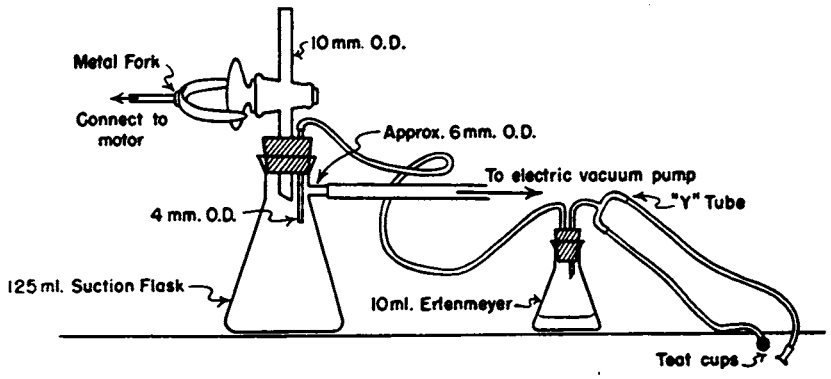

Fig. 1 Diagram of milking apparatus for guinea pigs.

minute) of Glimstedt et al. ('37). Any appreciably greater vacuum or more rapid pulsations may cause discomfort to the animal and a cessation of milk flow.

In the first milking tests, account was taken of the observation by Glimstedt et al. ('37) that the female ceases to lactate when the young are removed from the cage for periods longer than 24 hours. The young were removed at 9 A.M. and the mother was milked at 4 P.M. the same day and at 9 A.M. the following day. The young were returned to the cage for a period of 24 hours and the procedure repeated. In this manner regular milking intervals were established and are referred to as "alternate milkings."

Later, in order to obtain all the milk from the female guinea pig and at the same time maintain a high degree of lactation, the following method was employed: The cage ($7'' \times 17'' \times 9\frac{1}{2}''$) was divided by a wire mesh partition through which the pig could see and hear her young. The young were separated permanently from the mother by placing them on the opposite side of the partition immediately after parturition. If the young were born in the morning, the first milking was at 4 in the afternoon of the same day, but if born in the afternoon the first milking was at 9 in the morning of the next day. This method proved very successful and is referred to as "daily milking."

Constant conditions during milking are essential to obtain maximum yields. For this reason an attempt was made to keep environmental conditions constant and the effect of the time of milking and the operator at a minimum. Irregularity in yields over and above the anticipated production may be attributed to loss or morbidity of young, adverse milking conditions including too low a milking room temperature, sharp noises, other interruptions, and the disposition of the individual animal which made it unsuitable for milking. Prior to starting the milking procedure, the cage containing the mother and young was moved to a table on which the milking machine was assembled. The motor and vacuum pump were turned on and after a few minutes the female was gently removed and stroked for several minutes. The animal was slowly turned into a sitting position on the table, situated so her back would be supported against the operator's body. She could see her young in the cage. Concern of the female for her young was often shown while being milked. Before applying the teat cups the glands were massaged for one or two minutes. Both cups were attached at the same time. They were held between two fingers of each hand. The remaining fingers were available to massage the glands. The teat cups can be slightly pulled to stimulate flow of milk and to prevent congestion. This may be irritating, however, and should not be done if the animal objects. Pulling of the cup at the

close of milking was found to be advantageous in voiding the gland of the last of the milk. The massaging of the gland and the pulling of the cups was done in rhythm with the pulsations of the machine.

A small quantity of milk was usually obtained upon applying the teat cups. After two to 10 minutes a good flow of milk occurred, which in the dairy industry is referred to as the "letting down" of milk. The "let down" of milk in the guinea pig, especially in a good milker, is enhanced by constant conditions, so that the milk flows after the same interval and in the same manner at each milking. Milking was usually completed within several minutes. The flow of milk tends to stop suddenly, after which the pig becomes restless. Further milking after this time was impractical, as only a few drops of milk could be obtained. A continuous flow of milk was observed in some animals. The milk would flow in large quantities for several seconds and then would flow slowly but continuously for lengthy periods. Occasionally this type of milk flow changed to the usual pattern of the definite "let down." It was difficult to know when to stop milking of this latter type, for the animal may not become restless even after long periods of milking. This type of animal was milked the same length of time at each milking, usually 30 to 40 minutes.

Although some animals may not be easy to handle in the beginning, after a few periods of milking they usually respond without difficulty. Other animals can be milked readily at the start and during the process of "letting down" they are quiet, relaxed and sometimes emit noises.

Milk analyses and lactation performance

There were many individuals on the staff who were already engaged in making analyses of the kind desired. These staff members were asked to analyze a portion of the guinea pig milk. The results are shown in table 2. All of the analyses, except that for reduced ascorbic acid, were made on a composite sample of a number of guinea pig milkings. Reduced

ascorbic acid was measured on an aliquot taken immediately after each milking. Additional analyses were made on milk obtained by "alternate milkings." The results are shown in table 3. It will be noted that these values were obtained on

TABLE 2

The composition of a composite sample of guinea pig's milk

1.	Solids, %		16.44	
2.	Fat, %		3.92	
3.	Lactose, %		3.02	
4.	Ash, %		0.82	
5.	Protein, %		8.10	
6.	Casein, %		6.62	
7.	Whey protein, %		1.48	
8.	Non-protein nitrogen, %		0.19	
9.	Amino acids (mg/100 ml):			
	Arginine	800	Phenylalanine	607
	Histidine	380	Threonine	540
	Isoleucine	680	Tryptophan	280
	Leucine	1190	Basic tyrosine	720
	Lysine	1110	Acid tyrosine	600
	Methionine	300	Valine	940
10.	Fat characteristics:			
	Saponification number		196	
	Iodine number		79.5	
	Melting point °C.		25.2	
	Reichert Meissl number		0.41	
	Polenske number		1.47	
11.	Vitamins (values per 100 ml whole milk):			
	Vitamin A, μg		2	
	Carotenoids, μg		25	
	Riboflavin, μg (without hydrolysis)		405–423	
	Riboflavin, μg (with acid hydrolysis)		435	
	Thiamine, μg		50	
	Niacin, μg (without hydrolysis)		975	
	Niacin, μg (with acid hydrolysis)		1,110	
	Biotin, μg		4.5	
	Calcium pantothenate, μg		478	
	Folic acid total, μg		80	
	Folic acid free, μg		3	
	Reduced ascorbic acid, mg		28–54	
12.	Specific gravity 25°/25°		1.043	

TABLE 3

Daily milk and vitamin secretion in the lactating guinea pig

LACTATION DAY	FEMALE NUMBER	MILK YIELD			ASCORBIC ACID				RIBOFLAVIN [1]		NIACIN [1]		THIAMINE [1]	
		4 P.M.	9 A.M.	Total	4 P.M.	9 A.M.	Ave. 24-hr.	Total secreted	24-hr. sample	Total secreted	24-hr. sample	Total secreted	24-hr. sample	Total secreted
		gm	*gm*	*gm*	*mg/ml*	*mg/ml*	*mg/ml*	*mg*	*μg/ml*	*μg*	*μg/ml*	*μg*	*μg/ml*	*μg*
	730	3.20	6.57	9.77	0.663	0.590	0.62	6.0	8.50	83.0	2.37	23.2	0.29	2.8
1	720	3.63	7.07	10.70	0.513	0.553	0.53	5.8	5.47	58.5	2.07	22.1	0.25	2.7
	736	3.77	7.45	11.22	0.484	0.445	0.46	5.1	7.50	84.1	2.66	29.8	0.34	3.8
			Average	10.56			0.54	5.6		75.2		25.0		3.1
	730	7.89	5.19	13.08	0.228	0.304	0.26	3.4	3.64	47.6	13.80	180.5	0.44	5.8
3	720	11.42	7.29	18.71	0.273	0.298	0.28	5.3	3.47	64.9	13.65	255.4	0.70	13.1
	736	8.04	7.53	15.57	0.235	0.385	0.31	4.8	4.32	67.3	10.71	166.8	0.57	8.9
			Average	15.79			0.28	4.5		59.9		200.9		9.3
	730	4.10	2.96	7.06	0.405	0.468	0.43	3.0	3.72	26.3	17.52	123.7	0.57	4.0
5	720	3.44	4.18	7.62	0.395	0.468	0.43	3.3	4.59	35.0	18.15	138.3	0.57	4.0
	736	5.71	6.69	12.40	0.450	0.420	0.43	5.4	4.96	61.5	16.37	203.0	0.82	10.2
			Average	9.03			0.43	3.9		40.9		155.0		6.2
	730	1.41	4.08	5.49	0.300	0.263	0.28	1.5	6.59	36.2	14.60	80.2		
7	720	2.63	3.67	6.30	0.225	0.188	0.20	1.3	4.80	30.2	15.35	96.7	0.63	4.0
	736	4.00	4.92	8.92	0.305	0.455	0.38	3.5	5.41	48.3	19.65	175.3	0.88	7.8
			Average	6.90			0.29	2.1		38.2		117.4		5.9
	730	0.66	3.36	4.02	0.280	0.415	0.34	1.6	5.23	21.0	18.85	75.8	0.62	2.5
9	720	1.43	2.31	3.64	0.430	0.350	0.39	1.4	4.93	17.9	17.20	62.6		
	736	2.63	4.90	7.53	0.268	0.418	0.34	2.8	5.98	45.0	16.17	121.8	0.86	6.5
			Average	5.06			0.36	1.9		28.0		86.7		4.5

[1] Note: values are reported as micrograms per milliliter and total micrograms secreted in a 24-hour period.

the individual milkings and reflect the daily variation as well as total secretion of the various nutrients. All animals whose milk was used for chemical analyses were maintained on a stock ration consisting of oats, wheat and alfalfa hay supplemented with fresh green grass fed ad libitum daily. Typical lactation curves are presented in figure 2. The curve for "alternate milking" (curve A) showed a peak on the third

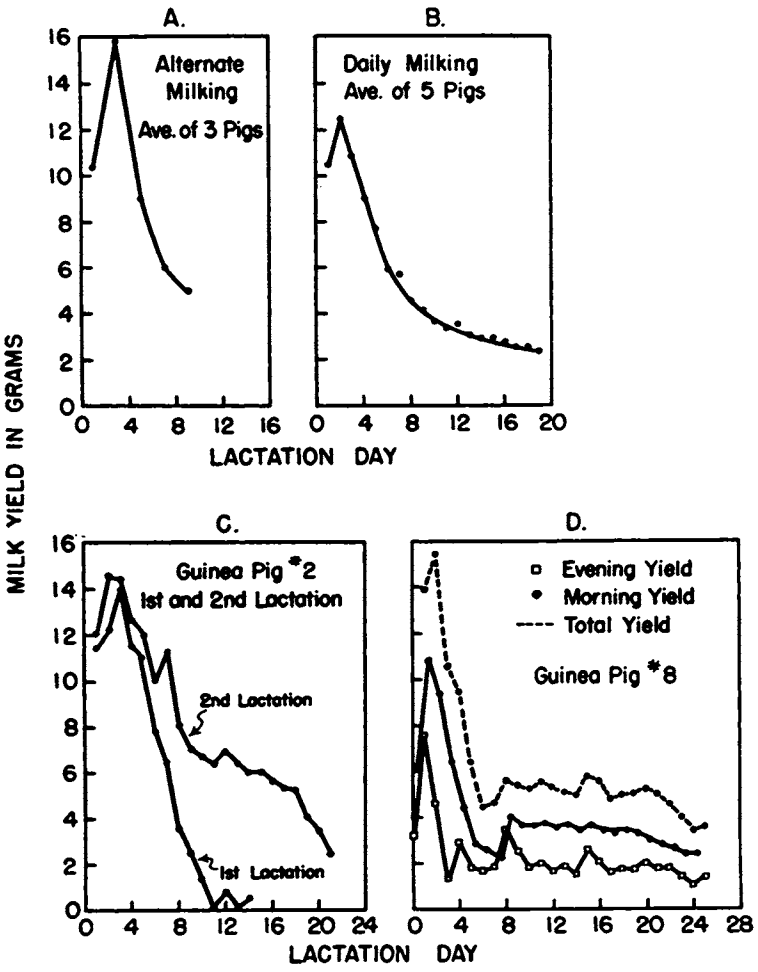

Fig. 2 Guinea pig lactation curves

day, or at the second milking of the animal. In most cases where the animal was milked daily (curves B, C, D) the peak occurred on the second day. The improved lactation performance of a guinea pig during her second lacation is shown in curve C. The relationship of evening and morning milk yield to the total daily yield is shown in curve D. These relationships are very similar to those reported for dairy cows.

DISCUSSION

There are some analyses of guinea pig milk in the literature (Neymark, '37; Abderhalden, 1899; Houston and Kon, '39; Engelbert, '45) which may be compared with the above. In general, there is good agreement except in the percentage of fat; others report fat contents of 5% or more. It should be recognized that there is considerable variation in the composition of the milk from different individuals of the same species, and from the same individual in different stages of lactation. This is well illustrated by the data reported in table 3. These data also point out the fallacy of attempting to show effects of diet on the composition of milk by reporting concentrations per 100 ml as the level of content of a nutrient in guinea pig milk when only an individual sample was taken. On this basis values for ascorbic acid range from 18.8 to 66.3 mg/100 ml, riboflavin from 364 to 850 μg/100 ml, for niacin from 207 to 1965 μg/100 ml and for thiamine from 25 to 88 μg/100 ml, and these variations are among individuals eating the same ration. Many analyses must be made to give a complete picture of the variations which may occur. The analyses in table 2 give no information regarding variation in composition but it is believed that they are based upon a most representative sample of guinea pig milk from our colony.

The lactation curves (fig. 2) and secretion data in table 3 indicate that the guinea pig can be used for measuring quantitatively the effect of diet on lactation performance. It is felt that the techniques described will permit a study of the various factors that may affect milk yield as well as nu-

trient composition. The procedure outlined above appears to obtain milk quantitatively from the lactating guinea pig in a manner similar to that usually employed for larger species such as the cow, goat or human. These techniques should provide a tool for studying lactation performance on a laboratory scale with savings of time, labor and expense.

SUMMARY

A milking machine of simplified design for use with small animals is described and the techniques used to obtain quantitative yields of milk during the entire lactation period of guinea pigs are discussed. Using these techniques, guinea pigs were milked for periods as long as 19 days without having nursed their young. A composite sample of guinea pig milk was analyzed for a larger number of constituents, and daily variations in milk yield, ascorbic acid, riboflavin and niacin concentrations are presented. Lactation curves for guinea pigs are presented which indicate that this animal is suitable for quantitative studies of the factors concerned with lactation.

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