EVALUATION OF THE GROSS ENERGY CONTENT IN THE MILK OF THE EQUINE

by

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ABSTRACT

Evaluation of the Gross Energy Content
In the Milk of the Equine

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Seven Quarter Horse mares were fed a balanced diet and milked at discrete intervals throughout a 150-day lactation. Samples were obtained by hand milking and were analyzed for gross energy concentration by oxygen bomb calorimetry.

Average milk energy concentration for seven observations on seven mares was 438.4 cal/gm ranging from 576.5 to 336.8 cal/gm. Highest energy concentration was observed at 10-days post-partum and the energy concentration tended to decline linearly over the course of lactation.

Total milk energy production averaged 5.110 mcal/day and ranged from 7.841 to 4.104 mcal/day. This curve also tended to decline linearly.

Simple correlation analyses showed milk energy concentration to be highly positively correlated with milk yield ($r=.71$, $P<.01$), fat ($r=.65$, $P<.01$), protein ($r=.81$, $P<.01$) and total solids ($r=.72$, $P<.01$).

The results of this study shows that milk energy concentration and total energy supply declines throughout lactation in mares and its variation is highly correlated to yield and organic milk components.

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CHAPTER I

INTRODUCTION

The modern horse industry has evolved in recent years into a dynamic, multi-million dollar segment of the American economy. Many serious horsemen take advantage of the monetary impact by making the horse business a profitable livelihood. As in any business, efficient and economical management is the key to producing a superior product; and like livestock producers, professional horsemen are now making use of available research to assist them in farm management.

One area of particular importance to the horse producer is maximizing foal production rates. Accurate knowledge concerning gestation, parturition, lactation and foal growth is paramount to maximum efficiency in the breeding business.

Past research with beef cattle has shown conclusively that milk production in the dam is singly the most important factor in weaning weight of the calf. It follows that the lactation characteristics would be of equal importance to the growth and maturation of a foal. Milk quality is also a significant factor in terms of nutrient supply for the foal. Sufficient energy is vital for optimum foal growth and the amount supplied to a foal via the milk is important to know in order to facilitate efficient creep feeding.

The primary objective of this study was to determine the energy concentration and the total energy supply in the mare's milk over the course of a lactation.

The citations on the following pages follow the format of the Journal of Animal Science.

CHAPTER II

REVIEW OF LITERATURE

Information in the area of milk composition in horses is extremely limited, and that which is available is rather inconsistent. Until recently the bulk of research done on milk composition was done abroad, particularly in the U.S.S.R. where mares' milk is an economically important commodity. In one of the first studies of milk composition, Kalliala, Seleste, and Hallman (1926) reported an energy concentration value of 38.5 kcal/100 ml of milk. Two decades later, Russian researchers Ollson and Ruudvere (1955) reported a value of 45 kcal/100 ml. German researchers Nesini, *et al.*, (1958) studied energy concentration over the course of lactation and reported values ranging from 66.1 to 47.05 kcal/100 ml. In a study at Michigan State, Ullrey *et al.*, (1966) analyzed milk energy concentration over the course of lactation and reported values that ranged from 1350 to 490 cal/gm.

Energy composition is probably highly related to other milk components in terms of variation over time. In a bovine study, Overmann and Sanmann (1926) reported simple correlation coefficients between energy and fat (r=.98) and energy and protein (r=.85). Tyrell and Reid (1965) also reported high correlation between energy and fat (r=.93) and energy and total solids (r=.96) in cattle. Energy and protein were not as highly related (r=.49).

Results of this study will add to current research information on milk energy concentration and correlation coefficients for energy and milk components in the horse.

CHAPTER III

OBJECTIVES

1. To quantify the gross energy concentration in mares' milk at discrete intervals during lactation.

2. To determine total energy supply at discrete intervals during lactation.

3. To estimate the lactation curve in terms of energy concentration and total energy supply.

4. To determine correlations between gross energy and other milk components.

5. To determine the correlation between energy concentration and milk yield.

CHAPTER IV

EXPERIMENTAL PROCEDURE

Samples utilized in this study were made available from a previous study (Gibbs, 1979) designed to determine yield and composition of mares' milk. In that study, seven Quarter Horse mares were fed a concentrate diet formulated to meet the requirements of a lactating mare (N.R.C., 1978) as seen in Table 1. Each mare received approximately 7.3 kg of concentrate per day and was adjusted appropriately to maintain constant body weight. Low quality (4.0% crude protein) bermuda grass hay was fed as roughage source at 10 kg/day and water was provided *ad libitum*.

Milk Sampling Techniques

Milk samples were taken at 10, 30, 45, 60, 90, 120 and 150 days of lactation. Foals were separated from the mares for three hours and then were permitted to nurse one teat while the other teat was hand-milked into a 100 ml plastic container. This technique was employed such that the suckling action of the foal stimulated complete milk let-down. The opposing teat was milked out completely and each sampling contained the complete milk supply resulting in a homogenous, and representative sample. This procedure was performed in the morning and repeated in the evening for each lactation interval. The two samples were blended, sub-sampled and frozen for storage.

Laboratory Procedure

Milk samples were analyzed for gross energy concentration using a

TABLE 1. COMPOSITION OF CONCENTRATE RATION**

Ingredients	International Ref. No.	Dietary Percentage
Corn	4-02-931	34.52
Oats	4-03-309	34.52
Soybean Meal	5-04-604	22.42
Molasses	4-04-696	7.00
Deflourinated Roch Phosphate	6-01-780	.37
Limestone	6-02-632	.68
Salt		.50
Vitamin A*		+
Calculated		
Crude Protein		17.00
Dig. Energy (mcal/kg)		2.97

*Diet supplemented with 2200 I.U. Vitamin A per kg diet.

**From Gibbs, 1979.

Parr adiabatic bomb calorimeter[1]. Samples were defrosted in a hot water bath to allow thawing and subsequent dispersion of fat globules. Experimental techniques were devised to convert the milk into a form that was acceptable for accurate bomb calorimetry. Bomb calorimetry does not effectively analyze sample in a liquid form. Therefore, samples were converted into solid form by adsorbing milk onto soluble starch followed by drying at 50°C. Approximately two mls of the thawed sample were pipetted directly into the bomb crucible containing a previously weighed amount of starch. The crucibles were again weighed for an accurate representative of sample on a weight basis. Duplicate samples were prepared and were placed in the drying oven and dried for 5-8 hours. These reduced drying temperatures were employed to prevent volatilization of fat. Once dried, the samples were placed in the bomb, charged with oxygen, burned and analyzed for energy content in the calorimeter. The starch energy content was subtracted from each value to yield energy concentration of the milk by differences.

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[1] Model 1242, Parr Instrument Company, Moline, Illinois.

CHAPTER V

RESULTS AND DISCUSSION

Milk Energy Concentration

Milk energy concentration was determined from seven points during lactation in seven mares. Energy concentrations at different stages of lactation are shown in Table 2.

Milk energy concentration averaged 438.4 cal/gm and ranged from 336.8 - 576.5 cal/gm over the five month lactation period. These values are higher than those reported by Kalliala, Seleste and Hallman (1926) and lower than those reported by Nesini, *et al.*, (1958) and Ullrey *et al.*, (1966). They are in close agreement with Ollson and Ruudvere (1955). The highest concentration occurred at 10-days post-partum. As seen in Figure 1, milk concentration decreased throughout the course of lactation with a slight increase seen at 150-days lactation. Due to sampling error, fat depression or incomplete sampling, the increase seen at 150-days is not significant. Therefore, the milk energy concentration decreased proportionately from early until late lactation in mares.

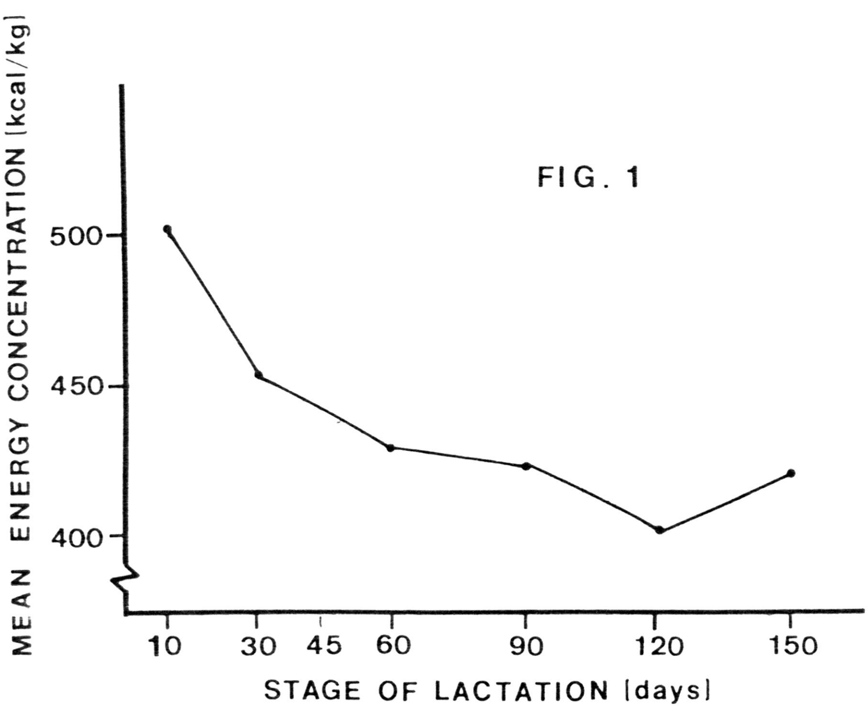
Milk Energy Yield

Total milk energy yield was computed from yield data on the same seven mares during the same lactation (Gibbs, 1979). These data are shown in Table 3. Yield and milk energy concentration values yielded total milk energy output for each mare at seven discrete intervals. These values are shown in Table 4.

Milk energy yield averaged 5.110 mcal/day and ranged from 4.104-7.841 mcal/day. As seen in Figure 2, total energy yield declined in linear

TABLE 2. EQUINE MILK ENERGY CONCENTRATION OVER A 150-DAY LACTATION

Stage of Lactation (days)	Energy Concentration (cal/gm)		
	Mean	Range	Std. deviation
10	500.2	459.4-576.5	51.2
30	452.7	427.7-486.7	60.8
45	442.5	409.8-505.9	36.0
60	427.8	404.7-479.9	28.3
90	423.4	336.8-472.2	50.0
120	401.5	392.1-421.3	13.5
150	420.6	369.2-493.8	50.7



ENERGY CONCENTRATION vs. STAGE OF LACTATION

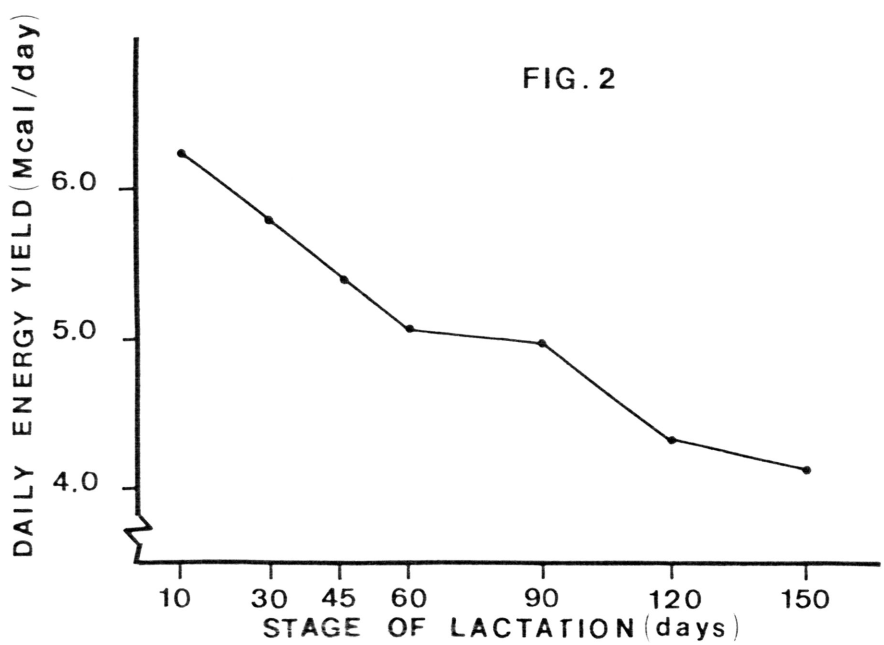
TABLE 3. MEAN DAILY EQUINE MILK YIELD OVER A 150-DAY LACTATION (kg/day)*

Stage of Lactation (days)	Mean Daily Milk Yield (kg/day)		
	Mean	Range	Std. deviation
10	12.36	10.7-13.6	1.1
30	12.77	11.1-13.6	1.5
45	12.11	11.6-13.4	.7
60	11.75	10.7-12.5	.7
90	11.63	10.2-13.0	1.2
120	10.75	9.8-13.6	1.9
150	9.7	8.4-10.7	.8

*From Gibbs, 1979.

TABLE 4. TOTAL MILK ENERGY YIELD IN MARES OVER A 150-DAY LACTATION (mcal/day)

Stage of Lactation (days)	Total Energy Yield (mcal/day)		
	Mean	Range	Std. deviation
10	6.214	5.115-7.841	1.12
30	5.780	4.876-6.958	.71
45	5.374	4.826-6.324	.67
60	5.030	4.614-5.999	.51
90	4.970	4.198-5.996	1.04
120	4.308	3.861-5.334	.69
150	4.104	3.100-5.283	.76



DAILY ENERGY YIELD vs. STAGE OF LACTATION fashion over the 150-day lactation.

Simple Correlations

Simple correlations between energy concentration, milk composition and yield were computed from these data and data reported by Gibbs (1979). These relationships are shown in Table 5.

Significant positive correlation is seen between milk energy concentration and milk yield. Significant relationship of energy to milk components is also evident. This analysis showed energy *vs* yield (r=.71, P<.01) to be highly significant as did energy *vs* fat (r=.65, P<.01), energy *vs* protein (r=.81, P<.01) and energy *vs* total solids (r=.72, P<.01). These significant relationships are lower than similar relationships reported by Tyrell and Reid, 1965; Overman and Sanmann, 1926. This may be explained by relatively wider variation in fat content of mares' milk (Gibbs, 1979).

GENERAL DISCUSSION

The lactation characteristics in terms of milk energy yield, concentration and correlation have not been studied a great deal in the equine. Energy concentration in mares' milk is of significance to the producer because of its importance in providing optimum growth of foals. Although it is commonly accepted that foals require additional nutrition at 90-days post-partum, studies on foal-growth and foal requirements in the first 90-days of life are virtually non-existent. Until a thorough investigation is completed on requirements of the foal, the exact limitation in energy supply to a foal from the milk of the mare cannot be quantified. However, these data will be useful to make such determinations when requirements are known.

TABLE 5. SIMPLE CORRELATIONS BETWEEN YIELD AND COMPONENTS OF MILK AND MILK ENERGY

	Gross energy
Milk yield	.71*
% fat	.65*
% protein	.81*
% total solids	.72*

*P<.01.

Milk energy concentration values reported here fall within the ranges of limited previous research. As lactation progressed, energy concentration in the milk tended to decline, as does milk yield (Gibbs, 1979) and thus, total energy supply decreased also.

The decreases seen in energy concentration support declining trends of other milk components (Gibbs, 1979). It is commonly held that concentrations of solid components tends to increase as yield decreases in beef cattle[2]. In this study samples were obtained by milking out the teat cistern while permitting the foal to nurse the opposing teat to facilitate let-down. Though the teat cistern was milked out as completely as possible, some component depression may have occurred due to incomplete emptying of the teat cistern. This milking method was probably most effective early in lactation when yields were high and then some error may have occurred in the latter stages when yield was significantly reduced (Gibbs, 1979). Seasonal effects may have had some influence on milk energy decline because of relatively high heat stress involved in later lactation due to summer temperatures.

It should be noted that these data and those Gibbs (1979) reported reflect the same trends as those reported by Ullrey, *et al.*, (1966) and Nesini, *et al.*, (1958). Therefore, it may very well be possible that concentration of milk nutrients declines with advancing lactation. If this is correct and combined with decreasing milk yield,daily production of energy by the lactating mare goes precipitately down as lactation advances. This possible supports the suspected need for creep feeding of foals at some time before weaning if maximum growth is to be achieved.

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[2]Gibbs, 1979.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This study was conducted as a continuation of previous research (Gibbs, 1979) by determining the energy concentration and total energy yield in mares' milk at discrete intervals during lactation. Also, correlation between energy and other milk components was determined.

Seven Quarter Horse mares were fed a diet consisting of corn, oats, and soybean meal formulated to meet N.R.C. (1978) requirements over a 150-day lactation. Yield and composition of milk characteristics was determined. Samples for composition analyses were obtained by hand-milking at 10, 30, 45, 60, 90, 120 and 150-days post-partum. Two samples were obtained for each interval studied at opposing ends of the day. They were mixed, sub-sampled and frozen for later analyses. Samples were thawed, blended and analyzed for gross energy using a Parr Adiabatic bomb calorimeter. Average milk energy concentration was 438.4 cal/gm and ranged from 336.87 to 576.5 cal/gm. A linear decline in milk energy over the course of lactation was evident.

Total milk energy yield ranged from 4.105-7.841 mcal/day and averaged 5.110 mcal/day. Highest energy yield occurred at 10 days post-partum, declined linearly, and reached its lowest point at 150 days.

Correlation of milk energy concentration to yield showed significant positive relationships ($r=.71$, $P<.01$) as did milk energy to fat ($r=.65$, $P<.01$), milk energy to protein ($r=.81$, $P<.01$) and milk energy to total solids ($r=.72$, $P<.01$).

Results of this study indicate milk energy concentration declines throughout the course of lactation as does total milk energy yield.

Energy concentration is highly positively correlated to yield and the organic milk components.

LITERATURE CITED

Gibbs, P.G.E. 1979. Yield and composition of milk from mares fed soy-bean meal or urea as protein supplements. M.S. Thesis. Texas A&M University.

Kalliala, H., E. Seleste and N. Hallman. 1951. On the use of mares milk in infant feeding aeta paediatr. Stockh. 40 94-117.

Nesini, R., Flade, Heidler and Steger. 1958. Yield and composition of mares milk over the course of lactation. Nutritional Abstract 29:1374.

NRC. 1978. Nutrient requirements of domestic animals No. 6. Nutrient Requirements of Horses.National Research Council. Washington D.C.

Olsson, N. and A. Ruudvere. 1955. The nutrition of the horse. NA 25 1-18.

Overman and F. D. Sanmann. 1926. The energy value of milk as related to composition. Illinois Agri. Exper. Station. Bull. 282.

Tyrell and Reid. 1965. Prediction of the energy value of cows milk. J. Dairy Sci. 48: 1215.

Ullrey, D. E., R. D. Struthers, D. G. Hendricks, B. E. Breret. 1966. Composition of mares' milk. J. Anim. Sci. 25:217.