

STUDIES ON KETOSIS IN DAIRY CATTLE. XII. BLOOD LIPIDS,
PHOSPHATES AND PHOSPHATASE ACTIVITY OF COWS
ON DIFFERENT LEVELS OF FEED
INTAKE POSTPARTUM¹

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A study of cows with ketosis (1) showed some alterations in the blood plasma lipids, phosphates and serum phosphatase activity. These alterations were more distinct in cases where cows had exhibited a ketotic condition for 10 days or more. Since these cows also exhibited inanition, which usually is associated with bovine ketosis, it was difficult to decide whether the alterations were due to the ketotic condition as such or to inanition.

For purposes of comparison, a study was made of the effects of inanition during the postpartal period while the researches on ketotic cows were still in progress.

EXPERIMENTAL PROCEDURE

At the time that this study was initiated rather extensive investigations were in progress in this laboratory relative to the effect of the quality and quantity of feed on the postpartal metabolism of the cow. The blood samples used in this study were drawn from these same animals.

For 6 mo. prior to parturition the cows all were fed rather heavily on low (10 per cent), medium (14 per cent) and high protein (23 per cent) rations. Following parturition half of the cows were fed liberally. The energy intake of the other half was limited to 35 per cent of Morrison's feeding standards for 8 to 15 days postpartum. In order to avoid repetition, the exact details relative to the feeding of these animals will be presented in a later paper together with the results of the studies for which these experiments originally were designed.

The chemical procedures used in this study are the same as those listed in the preceding paper (1).

RESULTS

Postpartal blood plasma lipid values from cows on different levels of protein and energy intake are presented in tables 1 and 2. The data shown in table 1 are from cows which received 70 per cent of Morrison's feeding standards for total digestible nutrients for the first week postpartum and 80 per cent during the second week postpartum. The level of protein in the ration did not exert any apparent effect upon the blood lipid values. When the postpartal plasma lipid values for the individual cows are subjected to a careful examination, it will be observed that at this level of feed intake there was a gradual increase in total lipids, phospholipids, total cholesterol, ester cholesterol and cholesterol esters, independent of the protein intake. Free cholesterol did not change appre-

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TABLE 1
Blood plasma lipids of cows on high plane of nutrition postpartum

Date	Cow	Total plasma lipids	Plasma phospholipids	Total plasma cholesterol	Plasma ester cholesterol	Plasma free cholesterol	Fatty acids in		Free acids	Remarks
							Cholesterol esters	Glycerol esters and as free		
		(mg. %)	(mg. %)	(mg. %)	(mg. %)	(mg. %)	(mg. %)	(mg. %)	(m. equiv./100 ml.)	
A. High protein ration										
8/ 4 48	Esmeralda	296.3	132.6	112.6	83.3	29.3	51.1	0.0	0.06	Prepartum
8/24 48	Esmeralda	.....	.....	103.7	79.9	23.8	.....	.....	0.07	Prepartum
8/27 48	Esmeralda	240.6	79.7	104.4	87.4	16.7	56.8	13.2	0.11	1 d. postpartum
9/17 48	Esmeralda	363.4	134.7	154.3	135.6	18.7	74.4	0.0	.....	22 d. postpartum
1/ 3 49	Ruby	302.2	.....	111.6	96.2	15.4	.....	.....	0.20	16 d. postpartum
1/17 49	Ruby	498.1	263.8	191.0	124.3	66.7	43.3	0.0	.....	30 d. postpartum
Av. 16 d. postpartum (Ruby)		302.2	.....	111.6	96.2	15.7	.....	.....	0.20	
B. Medium protein ration										
5/12 48	Bonita	250.0	76.6	82.3	.....	.....	.....	91.1	0.10	Prepartum
5/19 48	Bonita	243.8	80.9	87.4	.....	.....	.....	75.5	0.08	Prepartum
5/20 48	Bonita	.....	.....	90.4	.....	.....	.....	111.0	0.11	Day of parturition
5/26 48	Bonita	262.9	82.3	58.6	.....	.....	.....	122.0	0.15	6 d. postpartum
6/ 2 48	Bonita	311.0	109.9	67.2	.....	.....	.....	133.9	0.10	13 d. postpartum
7/22 48	Faith	336.2	148.9	122.9	84.5	38.4	54.9	9.5	0.05	Prepartum
7/28 48	Faith	306.2	122.7	129.1	100.3	28.8	54.4	0.0	0.04	Prepartum
8/11 48	Faith	281.8	78.9	114.0	96.7	17.3	62.9	26.0	0.18	4 d. postpartum
8/21 48	Faith	361.7	120.4	159.6	131.8	27.8	81.7	0.0	0.08	14 d. postpartum
Av. 13-14 d. postpartum		336.4	115.2	113.4	131.8	27.8	81.7	0.0	0.09	
C. Low protein ration										
8/11 48	Acacia	210.3	37.6	95.5	76.1	19.4	49.4	27.8	0.06	Prepartum
8/27 48	Acacia	295.2	116.3	120.0	105.8	14.2	58.9	0.0	0.10	5 d. postpartum
9/ 3 48	Acacia	334.0	123.4	120.1	114.0	16.1	74.1	6.4	0.06	12 d. postpartum
9/17 48	Acacia	355.4	90.1	184.8	174.5	10.3	80.5	0.0	0.06	26 d. postpartum
1/ 3 49	Pomona	243.5	.....	85.7	68.4	17.3	.....	.....	0.15	3 d. postpartum
1/17 49	Pomona	375.9	117.5	171.8	133.2	38.6	86.6	0.0	.....	20 d. postpartum
Av. 12 d. postpartum (Acacia)		334.0	123.4	130.1	114.0	16.1	74.1	6.4	0.06	
Av. of all three groups 12-16 d. postpartum		324.2	119.8	118.4	114.0	19.8	77.9	3.2	0.13	

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TABLE 2
Blood plasma lipids of cows on low plane of nutrition postpartum

Date	Cow	Total plasma lipids	Plasma phospho-lipids	Total plasma cholest-erol	Plasma ester cholest-erol	Plasma free cholest-erol	Fatty acids in		Free acids	Remarks
							Cholest-erol esters	Glycerol esters and as free		
		(mg. %)	(mg. %)	(mg. %)	(mg. %)	(mg. %)	(mg. %)	(mg. %)	(m. equiv./100 ml.)	
A. High protein ration										
6/ 9 48	Martha	286.7	87.9	93.8	.....	.....	.....	.....	0.09	Prepartum
6/22 48	Martha	238.7	74.5	89.8	68.7	21.1	45.6	28.8	0.14	9 d. postpartum
6/25 48	Martha	255.2	92.2	86.9	69.7	17.2	45.3	30.8	0.12	12 d. postpartum
6/28 48	Martha	247.9	86.5	80.9	68.7	12.2	60.3	20.2	0.13	15 d. postpartum
7/28 48	Beth	211.7	59.6	93.8	74.2	19.6	48.2	10.1	0.06	Prepartum
8/19 48	Beth	199.8	56.7	77.0	66.1	10.9	43.0	23.1	0.12	Prepartum
8/23 48	Beth	212.6	81.5	73.9	63.0	10.9	41.0	16.2	0.10	3 d. postpartum
8/31 48	Beth	239.4	74.5	93.8	81.1	12.7	52.7	18.4	0.18	11 d. postpartum
1/ 3 49	Lizzie	148.1	.....	88.1	69.2	18.9	.....	.....	0.13	11 d. postpartum
3/10 49	Elinor	250.0	56.7	102.2	88.1	14.1	57.3	33.8	0.05	Prepartum
4/ 1 49	Elinor	233.1	71.6	68.7	55.9	12.8	85.0	7.8	0.19	10 d. postpartum
Av. 8-15 d. postpartum ^a		216.9	76.8	84.1	68.8	15.3	62.7	17.6	0.15	
B. Medium protein ration										
5/ 5 48	Valencia	198.4	66.7	72.2	.....	.....	59.5	.....	0.13	Day of parturition
5/ 8 48	Valencia	233.2	54.6	88.0	.....	.....	90.6	.....	0.18	3 d. postpartum
5/12 48	Valencia	236.4	73.8	69.8	.....	.....	92.8	.....	0.11	7 d. postpartum
5/14 48	Valencia	250.9	90.8	90.6	.....	.....	69.5	.....	0.13	9 d. postpartum
5/17 48	Valencia	263.4	85.1	92.2	.....	.....	86.1	.....	0.13	12 d. postpartum
5/19 48	Valencia	241.4	80.9	95.5	.....	.....	65.0	.....	0.12	14 d. postpartum
7/13 48	Adventuress	260.5	76.6	91.7	77.5	14.2	50.3	41.9	0.07	Prepartum
7/22 48	Adventuress	208.4	59.6	72.7	64.2	8.5	41.7	34.4	0.06	Prepartum
7/28 48	Adventuress	174.7	60.3	77.5	59.3	18.2	38.5	58.7	0.04	Prepartum
8/ 2 48	Adventuress	179.2	71.6	67.0	57.2	9.8	37.2	3.4	0.08	1 d. postpartum
8/ 9 48	Adventuress	205.8	56.0	78.7	62.8	15.9	40.8	30.3	0.14	8 d. postpartum
8/13 48	Adventuress	231.0	57.4	89.8	67.7	22.1	57.5	26.3	0.20	12 d. postpartum
8/16 48	Adventuress	259.2	75.2	100.1	82.6	17.5	53.7	30.2	0.19	15 d. postpartum

TABLE 2 (continued)
Blood plasma lipids of cows on high plane of nutrition postpartum

Date	Cow	Total plasma lipids	Plasma phospho-lipids	Total plasma cholest-erol	Plasma ester cholest-erol	Plasma free cholest-erol	Fatty acids in		Free acids	Remarks
							Cholest-erol esters	Glycerol esters and as free		
		(mg. %)	(mg. %)	(mg. %)	(mg. %)	(mg. %)	(mg. %)	(mg. %)	(m. equiv./100 ml.)	
9/13 48	Bounty	248.8	73.0	94.1	82.8	11.3	53.8	27.9	0.14	1 d. postpartum
9/17 48	Bounty	297.8	120.6	117.2	110.2	7.0	60.0	0.0	0.10	5 d. postpartum
9/23 48	Bounty	309.4	111.3	116.4	98.2	18.2	63.8	17.9	0.15	11 d. postpartum
Av. 8-15 d. postpartum ^a		264.4	86.6	99.6	84.6	18.4	53.9	26.2	0.15	
C. Low protein ration										
6/ 9 48	Bunny	279.0	87.2	101.5	.....	.....	.....	90.3	0.10	Prepartum
6/22 48	Bunny	312.0	127.0	100.9	89.8	11.1	56.9	27.5	0.08	Prepartum
6/28 48	Bunny	239.9	83.0	88.6	71.3	17.3	46.3	22.0	0.09	1 d. postpartum
7/ 1 48	Bunny	254.6	129.8	89.8	73.0	16.8	35.0	0.0	0.14	4 d. postpartum
7/ 6 48	Bunny	254.1	120.6	87.4	47.2	40.2	30.7	15.4	0.10	9 d. postpartum
7/ 9 48	Bunny	210.1	61.0	70.8	57.0	13.8	37.0	41.3	0.15	12 d. postpartum
7/12 48	Bunny	248.1	98.6	70.6	69.7	0.9	45.3	33.6	0.09	15 d. postpartum
8/ 4 48	Remembrance	276.2	114.9	99.1	91.7	7.4	59.6	2.6	0.06	Prepartum
8/31 48	Remembrance	229.6	71.6	100.8	75.4	25.4	49.0	8.2	0.10	1 d. postpartum
9/ 3 48	Remembrance	259.0	92.2	92.4	79.7	12.7	51.8	22.6	0.13	4 d. postpartum
9/ 7 48	Remembrance	214.2	72.3	70.2	57.7	12.5	37.5	34.2	0.17	8 d. postpartum
2/18 49	Melanie	322.3	85.8	117.1	98.2	18.9	98.2	21.2	0.05	Prepartum
2/25 49	Melanie	285.7	24.1	146.6	130.3	16.3	84.6	30.4	0.08	Prepartum
3/ 2 49	Melanie	313.1	87.2	110.9	91.2	19.7	59.3	55.7	0.10	Prepartum
3/21 49	Melanie	222.7	47.5	71.3	63.3	8.0	41.1	62.8	0.15	9 d. postpartum
3/23 49	Melanie	226.6	53.9	106.6	86.9	19.7	56.5	9.6	0.20	11 d. postpartum
Av. 8-15 d. postpartum		225.4	72.1	78.5	63.6	14.9	41.3	33.5	0.14	
Av. of all three 8-15 d. postpartum		235.6	78.5	87.4	72.3	16.2	52.6	25.8	0.15	

^a The value for each cow used for calculating the group averages was the average of all values between 8 and 15 d. postpartum.

TABLE 3
Blood plasma lipids in early and late stages of ketosis and the effect of postpartum fasting on plasma lipids

	No. of cows	Total plasma lipids	Plasma phospho-lipids	Total plasma cholest-erol	Plasma ester cholest-erol	Plasma free cholest-erol	Fatty acids in		Free acids	
							Cholest-erol esters	Glycerol esters and as free		
		(mg. %)	(mg. %)	(mg. %)	(mg. %)	(mg. %)	(mg. %)	(mg. %)	(m. equiv./100 ml.)	
Early stage of ketosis (1-4 d.) ^a	2-4	269.3	89.2	116.2	91.9	24.2	54.1	9.9	64.0	0.10
Later stage of ketosis from 6th day on ^a	2-6	238.1	84.4	87.6	65.4	22.1	43.5	21.8	65.3	0.20
Cows on high plane of nutrition postpartum	4	324.2	119.8	118.4	114.0	19.8	77.9	3.2	81.1	0.13
Cows on low plane of nutrition postpartum	10	235.6	78.5	87.4	72.3	16.2	52.6	25.8	78.4	0.15
Cow starved for 8 d. postpartum	1	184.8	24.5	88.1	61.3	26.8	39.6	32.6	72.2	0.44

^a Data from (1)

ciably. There are insufficient values for free acids to draw any precise conclusions. However, it will be noted that the free acids are lower before than after parturition. Also, when the values for the cows on a low plane of nutrition postpartum (table 2) are compared to those on a higher plane of nutrition (table 1), the free acids usually were higher after the cows had been on a low energy intake for several days.

TABLE 4
Plasma phosphate and phosphatase values of cows on high and low planes nutrition postpartum

Date	Cow	Plasma acid-soluble P			Phosphatase activity	Remarks
		Inorg.	Org.	Total acid-soluble		
		(mg. %)	(mg. %)	(mg. %)	(units/100 ml.)	
A. Cows on high plane of nutrition postpartum						
9/ 3 48	Esmeralda	5.91	2.12	8.03		High protein feeding
9/17 48	Esmeralda	6.42	0.95	7.37		High protein feeding
12/ 3 48	Peggy	2.94	0.71	3.65		Medium protein feeding
12/ 4 48	Peggy	3.59	1.05	4.64		Medium protein feeding
2/11 49	Peggy	.....	.....	.....	3.07	Medium protein feeding
8/27 48	Acacia	3.91	1.58	5.49		Low protein feeding
9/ 3 48	Acacia	6.76	1.82	8.58		Low protein feeding
Av. of individual averages		4.92	1.37	6.29	3.07	
B. Cows on low plane of nutrition postpartum						
8/25 48	Beth	6.03	0.77	6.80		High protein feeding
8/31 48	Beth	4.20	0.86	5.06		High protein feeding
3/28 49	Elinor	.....	.....	.....	3.07	High protein feeding
4/ 1 49	Elinor	4.58	0.92	5.50	1.92	High protein feeding
9/17 48	Bounty	4.46	1.18	5.64		Medium protein feeding
9/20 48	Bounty	4.56	0.69	5.25		Medium protein feeding
8/31 48	Remembrance	4.88	1.92	6.80		Low protein feeding
9/ 9 48	Remembrance	4.05	0.72	4.77		Low protein feeding
3/21 49	Melanie	1.87	0.43	2.30	1.58	Low protein feeding
3/23 49	Melanie	3.59	0.83	4.32	1.41	Low protein feeding
3/28 49	Melanie	.....	.....	.....	2.22	Low protein feeding
Av. of individual averages		4.28	0.92	5.20	2.11	

The data in table 2 are from cows which received 35 per cent of Morrison's feeding standards for total digestible nutrients for from 8 to 15 days postpartum. The difference in the protein intake did not appear to influence the blood lipids. However, several of the lipid fractions were altered by the low energy intake. Whereas several of the plasma lipid fractions of the cows on the higher energy intake (table 1) increased markedly in the early postpartal period, these same fractions either decreased or exhibited but a slight increase when the energy intake was maintained at a low level (table 2). This picture is similar to the results obtained with cows in early and late stages of ketosis (1). For purposes of comparison, a summary is given in table 3 of the data in table 1 and 2 together

with a summary of the data previously presented on ketotic cows (1). Cows receiving 70 to 80 per cent of Morrison's feeding standards for total digestible nutrients presented a blood plasma lipid picture very similar to that of cows in the early stages of ketosis. The cows on the lower plane of nutrition postpartum showed a blood plasma lipid picture very similar to that found in cows which had exhibited ketosis for some period of time. Apparently, the alterations in blood plasma lipids observed in cows with ketosis are due to the inanition which is associated with ketosis, rather than to ketosis as such. For purposes of comparison a Guernsey cow was fasted completely for 8 days beginning 3 wk. postpartum. At the beginning of the fasting period the blood plasma lipid picture was as follows: total lipids, 278.4 mg. per cent; plasma phospholipids, 95.0 mg. per cent; cholesterol-glycerol ester plus free fatty acid fraction, 183.4 mg. per cent; and free acids, 0.12 milliequivalents per 100 ml. of plasma. These values appear to be about normal for a cow in this stage of lactation. The plasma lipid values after 8 days of fasting are shown in table 3. Complete fasting produced blood lipid changes of a similar nature but of a greater magnitude than was noticed in ketotic cows.

In table 4, some data are presented on blood plasma acid soluble phosphates of cows on high and low levels of energy intake postpartum. Fasting appeared to have little or no effect on the plasma acid soluble phosphates. These data are quite similar to those observed in cows with ketosis (1).

Values are presented on serum phosphatase activity of two cows which were partially fasted postpartum. These values were somewhat below normal during the fasting period, which indicates that the low values observed in ketotic cows (1) may have been due to inanition.

SUMMARY

To determine whether some of the alterations previously observed in the blood lipids and phosphatase values of cows with ketosis are due to ketosis *per se* or secondarily to the inanition associated with ketosis, 16 cows were used in a study of the effect of different levels of protein and energy intake postpartum. The postpartal plasma lipid values of cows receiving 70 to 80 per cent of their total digestible nutrient requirements were similar to those of cows in the early stages of ketosis. The postpartal plasma lipid values of cows receiving only 35 per cent of their total digestible nutrient requirements were similar to those of cows in the later stages of ketosis. Complete fasting for 8 days produced alterations of the same nature but of greater magnitude.

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REFERENCE

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