Influence of Ultra-violet Ray upon the Milking Cow

By

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Introduction

Many different experiments have been tried showing what will occur when ultra-violet ray irradiates on the bodies of cows and other animals as follows, BARTLETT, J. W.[1] and HART, E. B. STEENBOCK, H. SCOTT, H. and HUMPHREY, G. C.[4] concluded that there is no particular change upon the milk production though ultra-violet ray irradiating upon the body of a cow, and further HART, E. B. and his coworkers[4] MATTICK, A. T. R. and WRIGHT, N. C.[12] reported that there was no change of CaO and P_2O_5 in the milk secreted by an irradiated cow. On the contrary BARTLETT, J. W.[1] says that CaO in the milk afforded by the cow irradiated upon one hour per day increased a little but that P_2O_5 in the milk was unchanged.

Next, what relation exists between the milk afforded by the irradiated cow and the supply of vitamin? VÖLTZ, W. KIRSCH, W. and FALKENHEIM, C.[19] CHICK, H. and ROSCOE, M. H.[2] STEENBOCK, H. HART, E. B. HOPPERT, and BLACK,[18] and LUCK,[11] proved that there was a great increase of vitamin D in the milk secreted by the irradiated cow. Also HART, E. B. STEENBOCK, H. SCOTT, H. and HUMPHREY, G. C.[4] showed that the milking cow obtains the antirachitic vitamin from her food but that human, goat, chicken and perhaps mouse can get vitamin D directly from the short length waves of sunlight. Further HART, E. B. and his coworkers[5] reported that sunlight has little effect to offset the defect of food in maintaining the calcium balance in a cow. But HENDERSON, J. M.[7] by his experiment using a milking goat, concluded that ultra-violet ray has the power to change calcium negative balance into positive but that there is no change in the milk production.

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ORR, J. B. and his coworkers[13] examined the calcium balance by using the irradiated milking goat. They reported that the calcium balance becomes positive by the irradiation and that it is the result of an increased resorption of calcium into the intestines rather than the decreased excretion from the intestines.

HART, E. B. and his coworkers[6] also obtained just the same result. SALMON, W. D.[15] experimented with the calcium balance by using the milking goat giving cereal and wheat straw as the food. When the goat was irradiated the calcium balance became positive. LUCE, E. M.[10] proved that the milk afforded by the pasturing cow contained more antirachitic property as compared with the nonpasturing cow, and still further he proved that the milking cow needs the sunlight considered from the above standpoint.

GOLDBLATT, H. and his coworkers[3] reported that when the ultra-violet ray irradiates on the animal's food, especially in case of mouse it has the effect to increase its growth, and STEENBOCK, H. and his coworkers[16] concluded that the irradiated food not only increased the growth of mouse but also increased the bone calcifying property. STEENBOCK, H. and his coworkers[17] proved that the antirachitic property increases by the irradiation with ultra-violet ray and that the demand for the antirachitic matter of the chicken and milking goat is much greater than that of the mouse.

As shown above there have been many investigations about the irradiation of ultra-violet ray upon an animal's body and its food, but up to the present time we did not find a distinct determination about the milking cow, so we propose to investigate this problem by dividing it into three parts as follows:

I. Influence of ultra-violet ray upon the milk production of cow whose udder was irradiated.

II. Influence of ultra-violet ray upon the milk production of cow whose food was irradiated.

III. To discover the quantities of CaO and P_2O_5 in the milk afforded by the cow whose udder was irradiated.

Experiment I.

INFLUENCE OF ULTRA-VIOLET RAY UPON THE MILK PRODUCTION OF COW WHOSE UDDER WAS IRRADIATED

I. Experimental method

Feeding standard we used here is that of KELLNER's starch value. We divide it into two parts for convenience, first the maintenance food which is needed to maintain 1000 lbs. of live weight of cow secreting 10 lbs. of milk, second the food necessary for the milk production in addition to the 10 lbs. of milk produced each day. According to KELLNER, O. the cow of 1000 lbs. of live weight secreting 10 lbs. of milk needs 1.15 lbs. of digestible pure protein and 8.05 lbs. of starch value, and still further she needs 0.6 lbs. of digestible pure protein and 2.4 lbs. of starch value for producing 10 lbs. of milk only. Therefore we prepared the rations which we used for experiment, calculated accurately to satisfy this feeding standard.

We divided the total experimental periods into three, each period consisting of 15 days: 6 days for the preparation, 9 days for the main experiment.

There were three cows for the experimental use, two of them irradiated by using a quartz mercury vapor lamp (Hanovia) upon their udders, while the other one was not treated serving the purpose of a control animal. Presumably this control cow was convenient for noting what will happen upon the milk production by change of temperature and other conditions during all the experimental periods. Two cows were irradiated on their udders during only the second period. After these cows were led into a dark room and while standing quietly, the ultra-violet ray from a quartz mercury vapor lamp was irradiated upon the hind and the two sides of their udders each 30 minutes per day keeping at the distance of 25 cm. from the source of the ultra-violet ray.

After calculating the assumed second experimental result obtained from the averages of the first and third experimental results we compared this assumed one with the true experimental result. And still further by comparing the true experimental results of the irradiated cows with those of the control cow, we endeavoured to observe in more detail the influence of the ultra-violet ray on the milk production of these cows.

The live weights of the experimental cows were obtained by weighing on the settled large balance and the weight of milk by weighing on the milk spring balance scale. The fat percentage of the milk was determined by using the method of BABCOCK's fat test.

These experiments began the 19th of Jan. and ended the 3rd of Mar. 1928. During all this experimental time these cows were fed in the same barn, therefore we can say that there were not any changes of the temperature and influences of sunlight and food.

II. Cows for experimental use

All of these cows which we used for the experiments belonged to the pure Ayrshire breed and their gestation periods, the secreting milk weight and the live weights were almost the same. We took especial care of the conditions of health, appetite, and the milk secretion of the animals. One week before the beginning of the experiments all the cows were habituated to the food used during the experimental periods.

After we knew the milk secreting ability of the cows by giving enough of these foods, the authors determined the ration by means of KELLNER's feeding standard. During all of the experimental periods the cows were under the same feeding and management, and the milking was done by the same cowboy.

Now let us show some of the important history of these cows.

(TABLE 1)

Cow No.	Date of birth.	Date of gestation.	No. of gestations.	Date of mating.	Live weight.	Milk secreting weight per day.
97	Nov. 20, 1918	July 7, '27	6	Nov. 12, '27	900 lbs.	18.0 lbs.
111	Aug. 20, '21	Aug. 17, '27	3	Nov. 15, '27	900 lbs.	14.0 lbs.
114	Mar. 29, '22	Aug. 26, '27	3	Oct. 9, '27	920 lbs.	15.0 lbs.

III. Feeding and management

The amount of food necessary to maintain at 900 lbs. the cow while producing 10 lbs. of milk per day was as follows:

(TABLE 2)

Hay (timothy and orchard)	6.0 lbs.
Corn silage	40.0 lbs.
Wheat bran	3.0 lbs.
Amekasu (candy cake)	5.0 lbs.

0.5 lbs. of wheat bran was enough to produce 1.0 lbs. of milk per day and 70.0 gm of bone meal and salt were added to the concentrated food for each one of the cows. The cows drank enough water to satisfy their demands each day.

The cows which were irradiated with the ultra-violet Ray were No. 97 and No. 111 cows, the former cow was irradiated from 9:30 to 11:00 o'clock every morning during the second period and the latter cow was irradiated from 2:00 to 3:30 o'clock every afternoon.

The milking was done two times every day at 7 o'clock in the morning and at 4 o'clock in the afternoon.

IV. Experimental results

The experimental results of each cow which we obtained through all the experimental periods are as shown in the following table.

(TABLE 3)

Cow No.	No. 97			No. 111			No. 114		
Main experimental period.	I.	II.	III.	I.	II.	III.	I.	II.	III.
Total true milk weight. (lb.)	156.4	162.1	149.3	121.7	123.0	116.9	125.9	120.3	111.5
Total assumed milk weight. (lb.)		152.9			119.3			118.7	
Total true fat weight. (lb.)	6.49	6.86	6.09	4.94	5.34	4.89	5.16	5.11	4.80
Total assumed fat weight. (lb.)		6.29			4.90			4.98	
Live weight of cow at the end of each period. (lb.)	890.0	960.0	895.0	900.0	925.0	915.0	920.0	920.0	915.0

Further let us show these experimental results as curves in order to understand them more easily by Figs. 1, 2 and 3.

And still further we will show the experimental results which we obtained each day through all the experimental periods by diagrams at the end of this thesis.

V. Discussion

Now let us observe what results appeared upon the milk production from irradiating on cow's udder by noting the experimental results shown above.

During the first main experimental period cow No. 97 produced 156.4 lbs. of milk and 6.49 lbs. of butter fat, during the second 162.1 lbs. of milk 6.86 lbs. of butter fat and during the third 149.3 lbs. of milk and 6.09 lbs. of butter fat. By observing above experimental results of cow No. 97 we recognize that the second experimental result is better than the first and third experimental results. If we assume that this cow was not irradiated in the second period we can calculate this assumed result of the second period by dividing by two the total sum of the first and third experimental results. This will show 152.9 lbs. of milk and 6.29 lbs. of butter fat. When we compare this result with the true second experimental one the latter will show an increase of 9.2 lbs. (7.2%) of milk, 0.57 lbs. (9.06%) of butter fat and 67 lbs. in the live weight.

Again the same relative results were obtained in the case of cow No. 111, namely in the true second experimental period of this cow there is shown an increase of 3.7 lbs. (3.1%) of milk and 0.42 lbs. (8.53%) of butter fat as compared with the assumed second one. On the contrary when we notice the results of cow No. 114 which was not irradiated throughout all the experimental periods there were produced 125.9 lbs. of milk and 5.16 lbs. of butter fat in the first main experimental period, 120.3 lbs. of milk and 5.11 lbs. of butter fat in the second experimental period, while in the third period she produced only 111.5 lbs. of milk and 4.80 lbs. of butter fat.

Further we can say that the assumed numbers of cow No. 114 were just the same as the true experimental numbers, and still further there was shown a tendency to decrease her milk production as her lactation period come to an end. The live weight of this cow did not change through all the experimental periods.

Next let us show the average experimental results of cows No. 97 and No. 111 taken from the experimental results shown in table 3.

(TABLE 4)

Main experimental period.			I.	II. true	II. assumed	III.
Total milk weight,			139.1 lbs.	142.6 lbs.	136.1 lbs.	133.1 lbs.
Total butter fat weight.			5.72	6.10	5.61	5.49
Live weight at the end of experimental period.			895.0	943.0	900.0	905.0
Comparing the true result of the second experimental period with the assumed one.	Amount of increase and decrease.	Milk weight		6.5 (+)		
		fat weight		0.49 (+)		
		body weight		43.0 (+)		
	% of increase and decrease.	milk weight		4.77 (+)		
		fat weight		8.73 (+)		
		bod. weight		4.77 (+)		

By observing above table the authors recognize that the average experimental result of two cows No. 97 and No. 111 at the second period is better than the assumed average result, and that there is an increase of 6.5 lbs. (4.77%) of milk, 0.49 lbs. (8.73%) of butter fat and 43 lbs. (4.77%) of body weight. These facts clearly show us that the irradiation upon the cow's udder causes her to feel very comfortable and to stimulate the milk secreting gland cells resulting in an increase in her milk production.

VI. Conclusion

1. When the ultra-violet ray irradiates upon the cow's udder her movements become very quiet and though the cover of the quartz mercury vapor lamp is brought close to her body she does not shun it rather she seems to be more comfortable and to ruminate slowly on account of its approach.

2. When the ultra-violet ray irradiates upon the cow's udder at the distance of 25 cm. from the source of light from the back and both sides of her udder each 30 minutes per day, there are favorable influences upon the milk production, namely: it shows an increase of 4.77% of milk and 8.73% of butter fat and also that it is favorable to increase her body weight.

3. VÖLTZ, W. KIRSCH, W. and FALKENHEIM, C.(19) and many other investigators proved that the milk afforded by the cow irradiated with the quartz mercury vapor lamp contains more antirachitic property. From the above standpoint we recognize that the irradiation upon the cow's udder is significant in improving the quality of the milk.

Experiment II.

INFLUENCE OF ULTRA-VIOLET RAY UPON THE MILK PRODUCTION OF COW WHOSE FOOD WAS IRRADIATED

I. Experimental method

The experimental method which was used in this experiment is almost identical with the former one. But in this case the ultra-violet ray was irradiated on the cow's food instead of upon her udder, therefore there are some differences from the former experiment. The cows used here are the same ones used in the former experiment, and moreover the experimental results of the former third period are adapted to those of the first experimental period of this experiment.

In the second experimental period the ultra-violet ray was irradiated on the food which was given to cows No. 111 and No. 114. In the third experimental period the concentrated food and corn silage of the cow No. 97 was irradiated by the quartz mercury vapor lamp.

Thus, the assumed second experimental result for two cows No. 111 and No. 114 will be obtained by dividing the sum of the first and third experimental results. And by comparing this result with the true second experimental one we can recognize what influences appeared upon the milk production by the irradiation upon the cow's food. On the other hand, cow No. 97 served as a control animal for the irradiated cows during the first and second experimental period, but in the third experimental period the ultra-violet ray was irradiated on her food, so the assumed third experimental result will be obtained by calculating from the first and second experimental results, also by comparing this result with the third true experimental one of this cow we can see the influence of ultra-violet ray upon the milk production of this cow.

Ultra-violet ray was irradiated upon the cow's food keeping at the distance of 60 cm. from the source of the light one and half hours per day. During the period of irradiation the contents of the food were stirred two times in order that they might receive the ray universally into the food.

Total experimental period was forty-five days from 18th of Feb. to 2nd of Apr. 1928.

The feeding and management of these cows were just the same as in the former experiment.

II. Experimental results

The experimental results of each cow which were obtained through all the experimental periods are as shown in the following table.

(Table 5)

Cow No.	No. 97			No. 111			No. 114		
Main experimental period.	I	II	III	I	II	III	I	II	III
Total true milk weight. (lb.)	149.3	125.7	131.1	116,9	115.1	107.7	111.5	110.2	101,7
Total assumed milk weight. (lb.)			102.1		112.3			106.6	
Total true fat weight. (lb.)	6.09	5.39	5.43	4.89	4.87	4.56	4.80	4.84	4.37
Total assumed fat weight. (lb.)			4.69		4.73			4.59	
Live weight of cow at the end of each experimental period. (lb.)	895.0	610.0	940.0	915.0	920.0	930.0	915.0	925.0	945.0

Further let us show these experimental results as curves in order to understand them more easily in Figs. 1, 2 and 3.

And still further the authors will show the experimental results obtained each day through all the experimental periods in diagrams at the end of this thesis.

III. Discussion

Now let us observe what results appeared in the milk production of a cow by the irradiation on her food by noting the experimental results which are shown in table 5. We found that cow No. 111 produced 116.9 lbs. of milk and 4.89 lbs. of butter fat during the first main experimental period of 9 days, but by the irradiating on her food in the second experimental period she produced 115.1 lbs. of milk and 4.87 lbs. of butter fat, and in the third experimental period during which her food was not treated, she produced 107.7 lbs. of milk and 4.56 lbs. of butter fat. There is an increase of 2.8 lbs. (2.5%) of milk and 0.14 lbs. (2.9%) of butter fat shown by comparing the true second experimental result with the assumed one of 112.3 lbs. of milk and 4.73 lbs. of butter fat.

From cow No. 114 we obtained just the same relative experimental results as from cow No. 111, namely there was an increase of 3.6 lbs. (3.4%) of milk and 0.25 lbs. (5.4%) of butter fat.

Next there will be obtained the average experimental results of cows No. 111 and No. 114 by calculating the experimental results shown in table 5.

(Table 6)

Main experimental period.			I.	II.		III.
				true	assumed	
Total milk weight. (lb.)			114.2	112.7	109.5	104.7
Total fat weight. (lb.)			4.85	4.86	4.66	4.47
Live weight at the end of experimental period. (lb.)			915.0	923.0	927.0	938.0
Comparing the true result of the second experimental period with the assumed one.	Amount of increase and decrease.	Milk weight		3.2 (+)		
		Fat weight		0.2 (+)		
		Body weight		4.0 (−)		
	% of increase and decrease.	Milk weight		2.92 (+)		
		Fat weight		4.24 (+)		
		Body weight		0.41 (−)		

By observing above table, the milk production of the second true experimental period shows a little decrease as compared with that of the first experimental one, but the fat production of the second experimental period is a little more than that of the first. Therefore there is an increase of 3.2 lbs. (2.92%) of milk and 0.2 lbs. (4.24%) of butter fat in the second true main experimental period as compared with the assumed second period on account of the irradiation on the concentrated food.

On the contrary, in case of cow No. 97 the ultra-violet ray was not irradiated on her food in the first and second experimental periods and while during the second the milk production was decreased normally as compared with that of the first, yet on account of the irradiation on her concentrated food and corn silage during the third there was an increase of 29.0 lbs. (28.4%) of milk and 0.74 lbs. (15.9%) of butter fat during the 9 days of the main experimental period. Also the body weight of each experimental cow gradually increased a little, but the authors can not recognize that this fact was due to the irradiation on their food, but rather to their pregnancy. Thus clearly we have proved that the irradiation of the ultra-violet ray on cow's food is effective in increasing her milk production.

IV. Conclusion

1. When ultra-violet ray was irradiated upon the cow's food keeping at the distance of 60 cm. from the source of light for one and half hours per day while the contents of food were stirred up two times every 30 minutes, there was an increase of 2.92% of the total milk weight and 4.24% of the total butter fat weight in the average of the two cows.

2. The irradiation of ultra-violet ray not only on the concentrated food but also on corn silage was very effective in increasing the milk production of a cow. And though it was an experiment upon only one cow there was an increases of 28.4% of milk and 15.9% of butter fat.

Experiment III

TO DISCOVER THE QUANTITIES OE CaO AND P_2O_5 IN THE MILK AFFORDED BY THE COW WHOSE UDDER WAS IRRADIATED

I. Experimental method

In this experiment we used the milk which was investigated in regard to the influence of ultra-violet ray upon the milk production of cows when they were irradiated on their udders.

The milk samples of the first and last days of each main experimental period in the case of Experiment I. were taken for analysing their salt constituents. And we calculated the average experimental results of both days of each experimental period of every cow.

Then the assumed result of the second experimental period when cows were not treated by the ultra-violet ray will be obtained by dividing the sum of the first and third main experimental results by two, and by comparing these results with the true experimental results of the second period, we can recognize what changes appeared upon the constituents of the milk salts, especially CaO and P_2O_5 on account of the irradiation upon the cow's udder.

The chemical analysis of the milk salts in this experiment was carefully carried on by using the analytical method of HENRY DROOP RICHMOND[8] and OYAMA, S.[14]

II. Experimental results

The analytical results of the salt constituents in the milk of every cow in each period are as follows:

Fig. 1.

Curves of the experimental results of Cow No. 97.

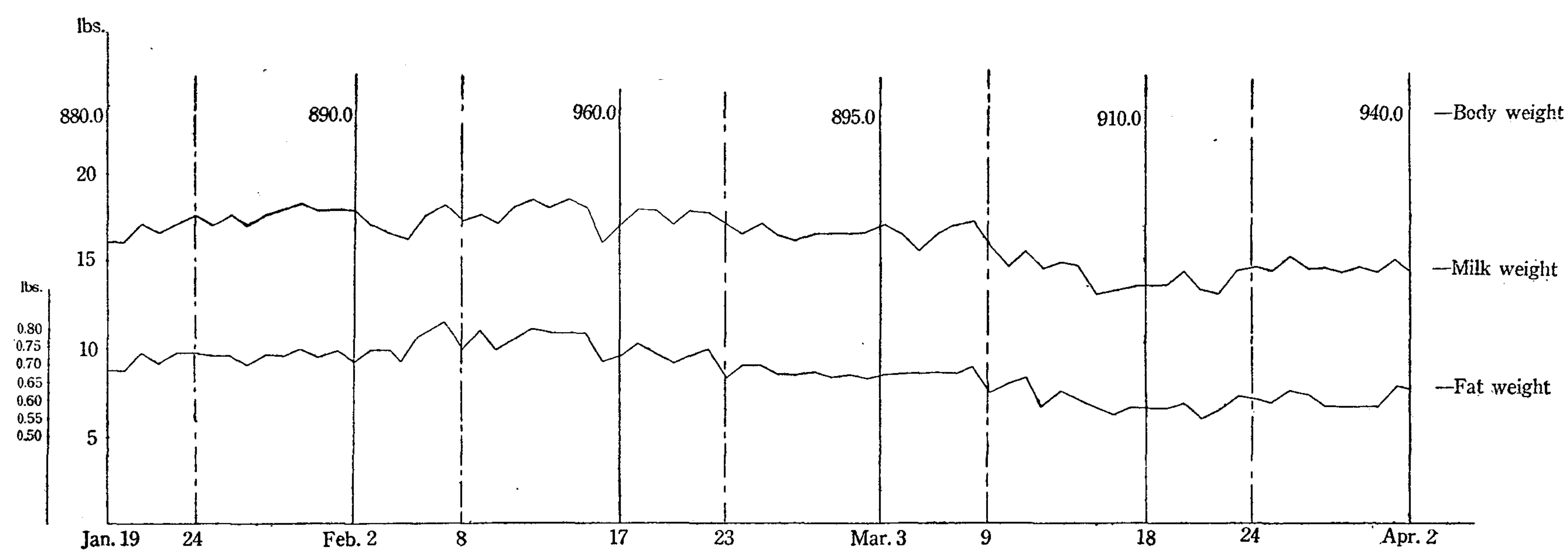


Fig. 2.

Curves of the experimental results of Cow No. 111.

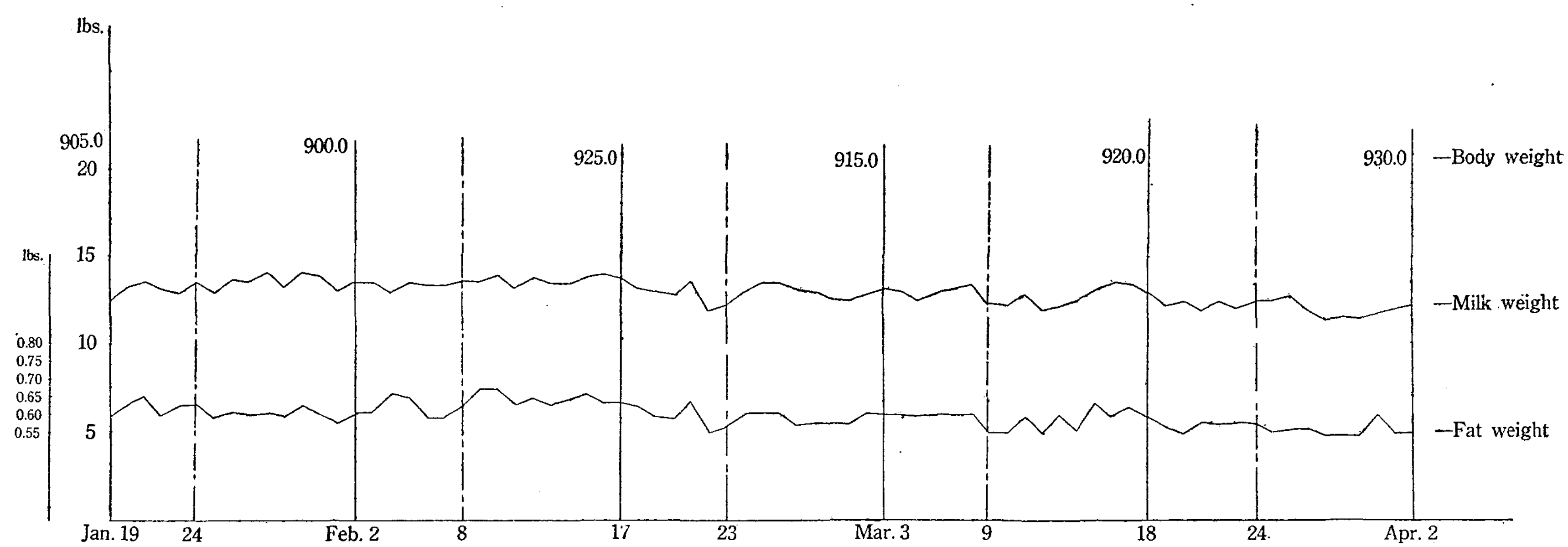
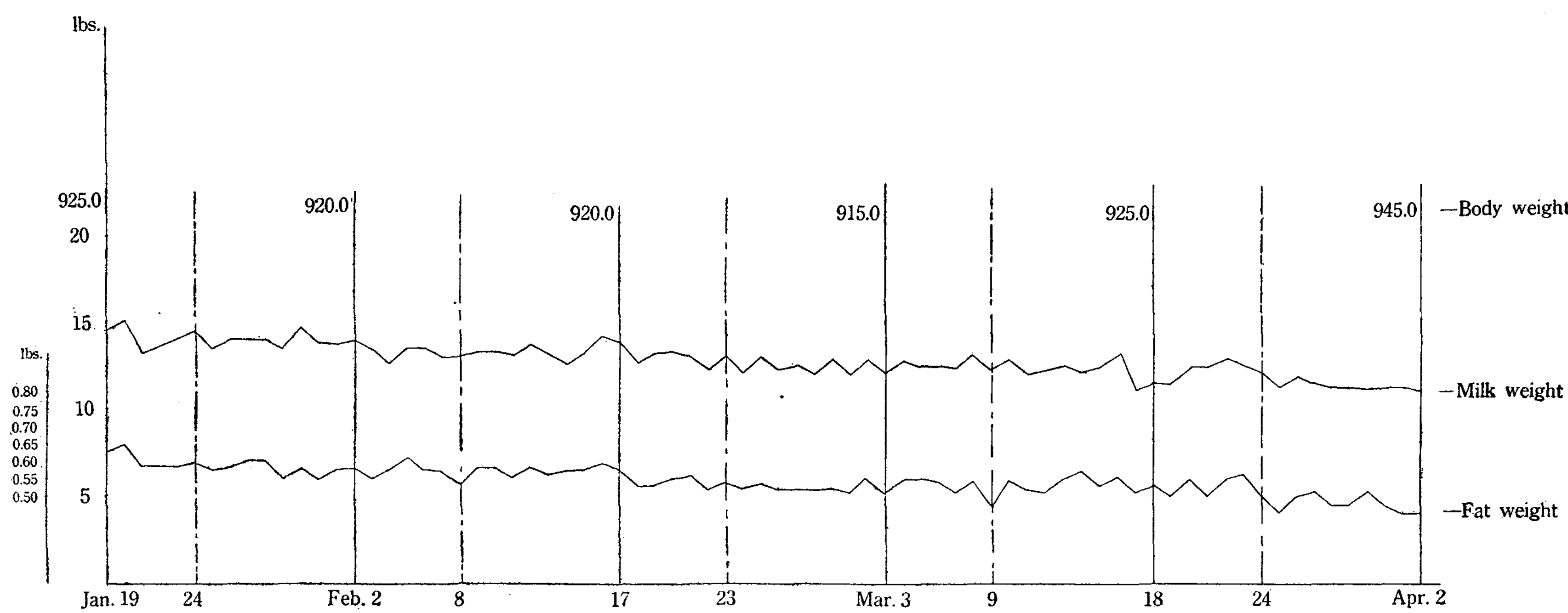


Fig. 3.

Curves of the experimental results of Cow No. 114.



(TABLE 7)

	Date	Cow No.	Dry matter %	ash %	Cl %	CaO %	MgO %	P_2O_5 %	SO_3 %	Fe_2O_3 %	Na_2O %	K_2O %
First Experimental period	Jan. 25, '28	97	12.040	0.740	15.160	19.960	2.404	28.931	1.930	0.296	6.165	25.013
	,,	111	11.342	0.787	11.522	20.305	2.710	34.488	1.984	0.303	6.055	23.570
	,,	114	11.100	0.728	14.856	18.876	2.634	30.820	1.862	0.288	6.985	25.264
	Feb. 3, '28	97	12.782	0.751	15.463	20.950	2.396	30.677	1.806	0.315	6.163	23.971
	,,	111	12.430	0.780	13.037	20.046	2.494	33.956	1.965	0.320	6.205	23.776
	,,	114	11.998	0.728	16.980	19.136	2.356	31.413	1.807	0.295	6.005	23.560
Second Experimental period	Feb. 9, '28	97	11.170	0.720	15.160	19.882	2.558	30.790	2.005	0.288	6.853	24.441
	,,	111	11.995	0.745	12.734	20.117	2.764	33.554	1.993	0.290	6.176	23.535
	,,	114	11.642	0.724	14.857	18.805	2.905	31.206	2.020	0.315	6.860	23.667
	Feb. 17, '28	97	12.958	0.800	15.076	21.264	2.623	29.286	1.960	0.321	6.163	24.505
	,,	111	12.578	0.827	11.915	19.468	2.806	34.975	2.115	0.305	6.623	23.805
	,,	114	12.269	0.763	15.281	19.995	2.472	30.901	2.221	0.315	6.802	22.570
Third Experimental period	Feb. 24. '28	97	12.558	0.728	14.555	20.279	2.729	30.153	2.030	0.288	7.138	23.650
	,,	111	12.260	0.740	12.128	20.470	2.904	33.818	2.125	0.301	6.965	22.424
	,,	114	12.800	0.720	16.615	19.991	2.559	30.443	1.980	0.290	6.860	22.753
	Mar. 3, '28	97	12.860	0.785	15.160	22.030	2.839	31.323	2.130	0.288	7.388	21.050
	,,	111	13.475	0.820	12.128	21.568	3.171	34.060	2.200	0.325	6.568	22.860
	,,	114	11.014	0.750	16.069	20.565	2.889	31.009	2.113	0.296	6.893	22.538

III. Discussion

It is a well known fact that as the lactation period of the cow progresses there is an increase in the milk salts, and also Cl, CaO, MgO and Na_2O in the milk, but on the contrary K_2O in it decreases.

Now let us calculate the average experimental result of each period by dividing the sum of the analytical results of the first and last days of each experimental period by two in order to understand more easily the experimental results which are shown in Table 7. Then the assumed result of the second experimental period will be obtained by dividing the sum of the first and third main experimental

(TABLE 8)

Cow No.	97				111				114			
Main experimental period.	first	second		third	first	second		third	first	second		third
		true	assumed			true	assumed			true	assumed	
dry matter %	12.411	12.564	12.560	12.709	11.886	12.287	12.127	12.367	11.549	11.856	11.728	11.907
ash ,,	0.746	0.760	0.752	0.757	0.784	0.786	0.782	0.780	0.728	0.743	0.732	0.735
Cl ,,	15.312	15.118	15.085	14.858	12.778	12.325	12.453	12.128	15.928	15.069	16.335	16.848
CaO ,,	20.460	20.573	20.807	21.154	20.176	19.792	20.677	21.019	19.006	19.400	19.617	20.228
MgO ,,	2.400	2.590	2.592	2.784	2.602	2.785	2.819	3.037	2.545	2.689	2.634	2.724
P_2O_5 ,,	29.862	30.039	29.950	30.738	34.222	34.264	34.000	33.939	31.117	31.054	30.921	30.726
SO_3 ,,	1.868	1.982	1.974	2.080	1.974	2.054	2.010	2.047	1.835	2.120	1.941	2.047
Fe_2O_3 ,,	0.306	0.305	0.297	0.288	0.311	0.297	0.312	0.313	0.292	0.315	0.273	0.253
Na_2O ,,	6.164	6.508	6.712	7.260	6.130	6.299	6.448	6.767	6.415	6.831	6.666	6.877
K_2O ,,	24.492	24.473	23.266	22.040	23.673	23.670	22.907	22.142	24.412	23.118	22.554	22.696

results by two. We will further compare the assumed result of the second experimental period with the true second experimental result in the following table.

According to the table 8 there is a tendency to increase dry matter and ash in the milk of cow No. 97 a little as her lactation period progresses, CaO MgO Na_2O, and SO_3 in the milk salts increase a little, Cl Fe_2O_3 and P_2O_5 remain constant, and K_2O decreases a little in the milk salts. The authors recognize that this fact is due to the normal change in the cow whose lactation period has passed the middle stage as explained above.

Now, when we compare the true second experimental results especially CaO and P_2O_5 in the milk salts with the assumed second one there are no significant changes in them. Moreover in the milk salts of cows No. 111 and No. 114 we recognize just the same phenomena as in the case of cow No. 97. These facts are the same with the experimental results of BARTLETT, J. W.[1] HART, E. B. and his coworkers[4] and MATTICK, A. T. R. and WRIGHT, N. C.[12].

According to the experiments[7] [13] [6] [15] made upon the milking goat, CaO and P_2O_5 in the milk salts show an increase on account of the irradiation by the ultra-violet ray upon her body. But in the milking cow the authors can not acknowledge any significant changes upon the constituents of CaO and P_2O_5 in the milk salts at the irradiation upon her udder.

IV. Conclusion

The constituents of CaO and P_2O_5 in the milk of cows are scarcely changed by the irradiation upon their udders each 30 minutes per day keeping at the distance of 25 cm. from the source of ultra-violet ray from the hind and both sides of their udders.

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Daily experimental records of cow No. 97.

Date	Milk weight (lb)			Fat %		Fat weight (lb)			Body weight (lb)
	morning	evening	total	morning	evening	morning	evening	total	
Jan. 19	10.0	6.0	16.0	3.8	5.0	0.38	0.30	0.68	880.0
20	10.0	6.0	16.0	3.8	5.0	0.38	0.30	0.68	
21	10.8	6.2	17.0	4.0	4.8	0.43	0.30	0.73	
22	10.6	6.0	16.6	3.9	5.0	0.41	0.30	0.71	
23	10.8	6.2	17.0	3.8	5.1	0.41	0.32	0.73	
24	11.5	6.0	17.5	3.9	4.8	0.44	0.29	0.73	
25	11.0	6.0	17.0	4.0	4.7	0.44	0.28	0.72	
26	11.0	6.5	17.5	3.7	4.7	0.41	0.31	0.72	
27	10.8	6.0	16.8	3.7	5.0	0.40	0.30	0.70	
28	11.0	6.4	17.4	3.7	4.8	0.41	0.31	0.72	
29	11.4	6.5	17.9	3.6	4.8	0.41	0.31	0.72	
30	12.3	6.0	18.3	3.6	5.0	0.44	0.30	0.74	
31	11.5	6.2	17.7	3.6	5.0	0.41	0.31	0.72	
Feb. 1	11.2	6.5	17.7	3.7	5.0	0.41	0.33	0.74	
2	11.0	6.6	17.6	3.7	4.7	0.40	0.31	0.71	
3	11.0	6.0	17.0	4.0	4.9	0.44	0.30	0.74	890.0
4	10.5	6.2	16.7	4.2	5.0	0.44	0.31	0.75	
5	10.2	6.0	16.2	3.8	5.3	0.39	0.32	0.71	
6	10.9	6.5	17.4	3.9	5.2	0.43	0.34	0.77	
7	11.3	6.8	18.1	4.4	4.9	0.50	0.33	0.83	
8	11.0	6.3	17.3	4.0	4.8	0.44	0.30	0.74	
9	11.5	6.2	17.7	4.2	5.2	0.48	0.32	0.80	
10	11.2	5.8	17.0	3.9	5.1	0.44	0.30	0.74	
11	12.0	6.0	18.0	4.0	4.8	0.48	0.29	0.77	
12	11.9	6.5	18.4	4.0	4.9	0.48	0.32	0.80	
13	11.3	6.7	18.0	4.0	4.9	0.45	0.33	0.78	
14	11.7	6.7	18.4	3.8	4.9	0.44	0.33	0.77	
15	12.0	6.0	18.0	3.8	5.1	0.46	0.31	0.77	
16	10.5	5.5	16.0	4.0	5.2	0.42	0.29	0.71	
17	11.0	6.0	17.0	3.8	5.0	0.42	0.30	0.72	
18	11.0	6.7	17.7	4.0	4.8	0.44	0.32	0.76	960.0
19	11.5	6.2	17.7	3.7	4.9	0.43	0.30	0.73	
20	11.0	6.0	17.0	3.7	4.9	0.41	0.29	0.70	
21	11.2	6.5	17.7	3.6	5.0	0.40	0.33	0.73	
22	11.0	6.5	17.5	3.8	5.0	0.42	0.32	0.74	
23	10.6	6.5	17.1	3.6	3.8	0.38	0.25	0.63	
24	10.2	6.5	16.7	3.7	5.0	0.38	0.32	0.70	
25	11.0	6.0	17.0	3.7	5.0	0.40	0.30	0.70	
26	10.8	5.5	16.3	3.9	4.7	0.42	0.26	0.68	
27	11.0	5.1	16.1	3.8	5.0	0.42	0.25	0.67	

Daily experimental records of cow No. 97. (Continued).

Date	Milk weight (lb)			Fat %		Fat weight (lb)			Body weight (lb)
	morning	evening	total	morning	evening	morning	evening	total	
Feb. 28	11.0	5.5	16.5	3.6	5.0	0.40	0.28	0.68	
29	11.0	5.5	16.5	3.6	4.8	0.40	0.26	0.66	
Mar. 1	11.0	5.5	16.5	3.7	4.8	0.41	0.26	0.67	
2	11.2	5.5	16.7	3.7	4.5	0.41	0.25	0.66	
3	11.0	6.0	17.0	3.5	4.7	0.39	0.28	0.67	
4	10.5	6.0	16.5	3.7	4.8	0.39	0.29	0.68	895.0
5	10.0	5.6	15.6	4.0	5.0	0.40	0.28	0.68	
6	10.5	6.0	16.5	3.8	4.8	0.40	0.29	0.69	
7	11.0	6.0	17.0	3.7	4.7	0.40	0.28	0.68	
8	11.2	6.0	17.2	3.7	4.8	0.41	0.29	0.70	
9	10.2	5.6	15.8	3.5	4.5	0.36	0.25	0.61	
10	9.0	5.2	14.2	3.9	5.2	0.36	0.27	0.63	
11	10.0	5.3	15.3	4.0	5.0	0.40	0.26	0.66	
12	9.0	5.2	14.2	3.7	4.7	0.33	0.24	0.57	
13	9.5	5.0	14.5	4.0	5.0	0.38	0.25	0.63	
14	9.3	5.0	14.3	3.8	5.0	0.35	0.25	0.60	
15	8.5	4.5	13.0	4.1	5.2	0.35	0.23	0.58	
16	8.3	5.0	13.3	3.7	5.0	0.31	0.25	0.56	
17	8.6	4.8	13.4	4.0	4.9	0.34	0.24	0.58	
18	9.0	4.5	13.5	4.0	4.9	0.36	0.22	0.58	
19	8.5	5.0	13.5	3.9	5.1	0.33	0.25	0.58	910.0
20	9.0	5.4	14.4	3.8	4.6	0.34	0.25	0.59	
21	8.8	4.5	13.3	3.8	4.8	0.33	0.22	0.55	
22	8.7	4.4	13.1	4.0	5.0	0.35	0.22	0.57	
23	9.2	5.2	14.4	4.0	4.8	0.37	0.25	0.62	
24	9.0	5.9	14.9	3.8	4.5	0.34	0.27	0.61	
25	9.5	5.0	14.5	3.8	4.5	0.36	0.23	0.59	
26	10.0	5.2	15.2	3.8	4.6	0.38	0.24	0.62	
27	9.6	5.0	14.6	3.9	4.8	0.37	0.24	0.61	
28	9.5	5.0	14.5	3.7	4.5	0.35	0.23	0.58	
29	8.7	5.5	14.2	3.8	4.5	0.33	0.25	0.58	
30	9.0	5.5	14.5	3.8	4.6	0.34	0.25	0.59	
31	9.0	5.3	14.3	3.4	5.0	0.31	0.27	0.58	
Apr. 1	9.0	6.0	15.0	4.0	4.9	0.36	0.29	0.65	
2	8.5	5.8	14.3	3.9	5.1	0.33	0.30	0.63	940.0

Daily experimental records of cow No. 111.

Date	Milk weight (lb)			Fat %		Fat weight (lb)			Body weight (lb)
	morning	evening	total	morning	evening	morning	evening	total	
Jan. 19	8.0	4.6	12.6	3.8	5.3	0.30	0.24	0.54	905.0
20	9.0	4.3	13.3	3.9	5.2	0.35	0.22	0.57	
21	9.0	4.5	13.5	4.0	5.4	0.36	0.24	0.60	
22	8.5	4.6	13.1	3.7	5.0	0.31	0.23	0.54	
23	8.2	4.5	12.7	3.9	5.3	0.32	0.24	0.56	
24	9.0	4.6	13.6	3.8	5.1	0.34	0.23	0.57	
25	8.0	4.8	12.8	3.8	4.8	0.30	0.23	0.53	
26	8.7	5.0	13.7	3.7	4.8	0.32	0.24	0.56	
27	8.5	5.5	14.0	3.7	4.6	0.31	0.25	0.56	
28	8.5	5.0	13.5	3.6	4.7	0.31	0.24	0.55	
29	8.5	4.8	13.3	3.5	5.0	0.30	0.24	0.54	
30	9.5	4.5	14.0	3.6	5.0	0.34	0.23	0.57	
31	9.0	4.8	13.8	3.6	4.8	0.32	0.23	0.55	
Feb. 1	8.5	4.5	13.0	3.7	4.7	0.31	0.21	0.52	
2	8.6	5.0	13.6	3.8	4.8	0.31	0.24	0.55	
3	8.5	5.0	13.5	3.6	5.0	0.31	0.25	0.56	900.0
4	7.5	5.5	13.0	4.3	5.3	0.32	0.29	0.61	
5	8.0	5.5	13.5	4.3	4.7	0.34	0.26	0.60	
6	8.2	5.0	13.2	3.5	5.0	0.29	0.25	0.54	
7	8.2	5.0	13.2	3.8	4.5	0.31	0.23	0.54	
8	8.3	5.4	13.7	3.8	4.7	0.32	0.25	0.57	
9	8.7	5.0	13.7	4.1	5.2	0.36	0.26	0.62	
10	8.3	5.6	13.9	3.8	5.1	0.32	0.29	0.61	
11	8.9	4.5	13.4	3.8	5.2	0.34	0.23	0.57	
12	8.5	5.5	13.5	3.9	4.8	0.31	0.27	0.58	
13	8.0	5.5	13.5	3.9	4.8	0.31	0.27	0.58	
14	8.0	5.3	13.3	4.1	4.9	0.33	0.26	0.59	
15	8.6	5.2	13.8	4.0	5.1	0.34	0.27	0.61	
16	8.5	5.5	14.0	3.8	4.7	0.32	0.26	0.58	
17	8.5	5.2	13.7	3.8	5.1	0.31	0.27	0.58	
18	8.2	5.0	13.2	3.9	4.9	0.32	0.25	0.57	925.0
19	8.5	4.5	13.0	3.8	4.9	0.32	0.22	0.54	
20	8.5	4.2	12.7	3.8	5.0	0.32	0.21	0.53	
21	8.6	5.0	13.6	3.7	5.1	0.32	0.26	0.58	
22	8.0	4.2	12.2	3.7	5.0	0.30	0.20	0.50	
23	8.0	4.5	12.5	3.6	4.9	0.29	0.22	0.51	
24	8.0	5.0	13.0	4.0	4.8	0.32	0.24	0.56	
25	8.5	5.0	13.5	3.7	5.0	0.31	0.25	0.56	
26	8.4	5.0	13.4	3.8	4.8	0.32	0.24	0.56	
27	8.3	4.8	13.1	3.6	4.8	0.30	0.23	0.53	

Daily experimental records of cow No. 111. (Continued).

Date	Milk weight (lb)			Fat %		Fat weight (lb)			Body weight (lb)
	morning	evening	total	morning	evening	morning	evening	total	
Feb. 28	8.5	4.5	13.0	3.6	4.8	0.31	0.22	0.53	
29	8.0	4.5	12.5	3.7	5.0	0.30	0.23	0.53	
Mar. 1	7.8	4.7	12.5	3.8	4.8	0.30	0.22	0.52	
2	8.0	4.9	12.9	3.9	5.0	0.31	0.24	0.55	
3	8.1	5.0	13.1	3.6	5.0	0.29	0.25	0.54	
4	8.0	5.0	13.0	3.7	5.1	0.30	0.25	0.55	915.0
5	8.0	4.6	12.6	3.9	5.0	0.31	0.23	0.54	
6	8.0	5.0	13.0	3.8	4.9	0.30	0.25	0.55	
7	8.0	5.2	13.2	3.6	5.0	0.29	0.26	0.55	
8	8.0	5.4	13.4	4.0	4.5	0.32	0.24	0.56	
9	8.0	4.4	12.4	3.5	4.8	0.28	0.21	0.49	
10	8.0	4.2	12.2	4.0	4.9	0.32	0.18	0.50	
11	8.2	4.6	12.8	3.9	4.9	0.32	0.23	0.55	
12	8.0	4.0	12.0	3.8	5.0	0.30	0.20	0.50	
13	8.0	4.2	12.2	4.2	5.2	0.34	0.22	0.56	
14	8.4	4.2	12.6	3.8	4.5	0.32	0.19	0.51	
15	8.6	4.6	13.2	4.0	5.0	0.35	0.23	0.58	
16	8.5	5.2	13.7	3.7	4.7	0.31	0.24	0.55	
17	8.4	5.0	13.4	3.8	5.0	0.32	0.25	0.57	
18	8.0	5.0	13.0	3.6	5.3	0.29	0.26	0.55	
19	7.8	4.5	12.3	3.7	4.6	0.29	0.21	0.50	920.0
20	7.5	5.0	12.5	4.1	5.0	0.31	0.25	0.56	
21	8.0	4.0	12.0	3.6	5.2	0.29	0.21	0.50	
22	8.0	4.5	12.5	3.7	5.0	0.30	0.23	0.53	
23	7.8	4.3	12.1	4.0	4.8	0.31	0.21	0.52	
24	8.0	4.5	12.5	4.0	4.7	0.32	0.21	0.53	
25	8.0	4.6	12.6	3.8	4.6	0.30	0.21	0.51	
26	7.9	4.9	12.8	3.6	4.8	0.28	0.24	0.52	
27	7.4	4.5	11.9	4.0	5.0	0.30	0.23	0.53	
28	7.0	4.5	11.5	3.8	4.6	0.27	0.21	0.48	
29	7.0	4.5	11.5	3.9	4.8	0.27	0.22	0.49	
30	7.0	4.5	11.5	3.9	4.9	0.27	0.22	0.49	
31	7.2	4.5	11.7	3.5	5.1	0.25	0.23	0.48	
Apr. 1	7.0	5.0	12.0	3.7	4.6	0.26	0.23	0.49	
2	7.2	5.0	12.2	3.5	4.9	0.25	0.24	0.49	930.0

Daily experimental records of cow No. 114.

Date	Milk weight (lb)			Fat %		Fat weight (lb)			Body weight (lb)
	morning	evening	total	morning	evening	morning	evening	total	
Jan. 19	8.4	6.0	14.4	3.8	5.0	0.32	0.30	0.62	925.0
20	10.0	5.0	15.0	4.0	4.8	0.40	0.24	0.64	
21	8.1	5.0	13.1	3.9	5.1	0.32	0.26	0.58	
22	8.0	5.6	13.6	3.9	4.9	0.31	0.27	0.58	
23	9.0	5.0	14.0	3.9	4.6	0.35	0.23	0.58	
24	9.5	5.0	14.5	3.7	4.7	0.35	0.24	0.59	
25	9.0	4.4	13.4	3.8	4.9	0.34	0.22	0.56	
26	9.0	5.0	14.0	3.6	5.1	0.32	0.26	0.58	
27	8.0	6.0	14.0	3.7	5.0	0.30	0.30	0.60	
28	9.0	5.0	14.0	4.0	4.8	0.36	0.24	0.60	
29	8.4	5.0	13.4	3.6	5.0	0.30	0.25	0.55	
30	9.9	4.8	14.7	3.6	4.8	0.36	0.22	0.58	
31	9.0	4.8	13.8	3.6	4.8	0.32	0.23	0.55	
Feb. 1	8.8	4.9	13.7	3.7	4.8	0.33	0.24	0.57	
2	9.3	4.6	13.9	3.8	4.9	0.35	0.22	0.57	
3	9.0	4.5	13.5	3.7	4.8	0.34	0.21	0.55	920.0
4	8.5	4.2	12.7	4.1	5.2	0.35	0.22	0.57	
5	8.5	5.0	13.5	4.1	5.3	0.35	0.26	0.61	
6	8.0	5.6	13.6	3.7	4.8	0.30	0.27	0.57	
7	8.0	5.0	13.0	3.9	4.8	0.31	0.24	0.56	
8	8.0	5.0	13.0	3.6	4.5	0.29	0.23	0.52	
9	8.0	5.2	13.2	3.7	5.0	0.30	0.26	0.56	
10	8.2	5.1	13.3	3.6	5.2	0.30	0.27	0.57	
11	8.8	4.4	13.2	3.8	5.0	0.33	0.22	0.55	
12	8.2	5.5	13.7	3.8	5.0	0.31	0.27	0.58	
13	8.0	5.2	13.2	3.8	5.0	0.30	0.26	0.56	
14	7.6	5.0	12.6	4.0	5.1	0.30	0.26	0.56	
15	8.5	4.7	13.2	3.9	5.0	0.33	0.24	0.57	
16	9.2	5.0	14.2	3.7	4.9	0.34	0.25	0.59	
17	8.7	5.0	13.7	3.6	4.9	0.32	0.25	0.57	
18	7.5	5.0	12.5	3.7	4.8	0.28	0.24	0.52	920.0
19	8.5	4.5	13.0	3.6	4.8	0.31	0.22	0.53	
20	8.2	5.0	13.2	3.6	5.0	0.30	0.25	0.55	
21	7.8	5.2	13.0	4.0	4.9	0.31	0.25	0.56	
22	7.8	4.3	12.1	3.9	4.9	0.30	0.21	0.51	
23	8.0	5.0	13.0	3.8	5.1	0.30	0.25	0.55	
24	7.5	4.5	12.0	4.0	5.0	0.30	0.23	0.53	
25	8.0	5.0	13.0	3.7	5.0	0.30	0.25	0.55	
26	7.5	4.8	12.3	3.8	5.1	0.29	0.24	0.53	
27	8.0	4.5	12.5	3.7	5.1	0.30	0.23	0.53	

Daily experimental records of cow No. 114. (Continued).

Date	Milk weight (lb)			Fat %		Fat weight (lb)			Body weight (lb)
	morning	evening	total	morning	evening	morning	evening	total	
Feb. 28	7.5	4.5	12.0	4.0	5.2	0.30	0.24	0.54	
29	7.8	5.0	12.8	3.7	5.0	0.29	0.25	0.54	
Mar. 1	7.8	4.2	12.0	3.9	5.0	0.30	0.21	0.51	
2	8.4	4.5	12.9	3.8	5.0	0.32	0.23	0.55	
3	7.5	4.5	12.0	3.8	5.2	0.29	0.23	0.52	
4	7.8	5.0	12.8	3.8	5.1	0.30	0.26	0.56	915.0
5	7.5	5.0	12.5	3.9	5.1	0.29	0.26	0.55	
6	7.5	5.0	12.5	4.0	4.8	0.30	0.24	0.54	
7	8.0	4.4	12.4	3.7	5.0	0.29	0.22	0.51	
8	8.0	5.2	13.2	3.7	5.0	0.29	0.26	0.55	
9	8.0	4.2	12.2	3.5	4.6	0.28	0.17	0.45	
10	8.0	4.9	12.9	3.8	5.0	0.31	0.25	0.56	
11	8.0	4.0	12.0	4.0	5.1	0.32	0.20	0.52	
12	8.0	4.2	12.2	3.7	5.0	0.30	0.21	0.51	
13	7.5	5.0	12.5	4.0	5.0	0.30	0.25	0.55	
14	8.2	4.0	12.2	4.5	5.2	0.37	0.21	0.58	
15	7.7	4.7	12.4	3.8	5.0	0.29	0.24	0.53	
16	8.2	5.0	13.2	3.9	4.7	0.32	0.24	0.56	
17	7.3	4.0	11.3	4.2	5.0	0.31	0.20	0.51	
18	7.5	4.0	11.5	4.2	5.0	0.32	0.20	0.52	
19	7.0	4.5	11.5	4.1	4.7	0.29	0.21	0.50	925.0
20	7.0	5.7	12.7	3.9	4.7	0.28	0.27	0.55	
21	8.3	4.2	12.5	4.1	4.6	0.24	0.26	0.50	
22	8.0	5.0	13.0	3.6	4.8	0.29	0.24	0.53	
23	7.5	4.9	12.4	4.0	4.8	0.30	0.24	0.54	
24	7.5	4.6	12.1	3.8	4.6	0.29	0.21	0.50	
25	7.0	4.3	11.3	3.6	4.7	0.25	0.20	0.45	
26	7.0	4.9	11.9	3.8	4.6	0.27	0.23	0.50	
27	7.0	4.5	11.5	4.0	5.0	0.28	0.28	0.56	
28	6.8	4.5	11.3	3.8	4.6	0.26	0.21	0.47	
29	7.2	4.0	12.2	4.0	4.8	0.28	0.19	0.47	
30	6.6	4.5	11.1	4.2	5.1	0.28	0.23	0.51	
31	6.7	4.5	11.2	3.4	5.2	0.23	0.23	0.46	
Apr. 1	7.2	4.0	11.2	3.6	4.8	0.26	0.19	0.45	
2	7.0	4.0	11.0	3.4	5.2	0.24	0.21	0.45	945.0