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Effects of Alkali Water on Dairy Products

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AGRICULTURAL EXPERIMENT STATION

SOUTH DAKOTA
STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

DAIRY HUSBANDRY DEPARTMENT

Effects of Alkali Water on Dairy Products

BROOKINGS, SOUTH DAKOTA

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EFFECTS OF ALKALI WATER ON DAIRY PRODUCTS

Effects of Alkali Water on Dairy Products

By

C. Larsen, Wm. White, D. E. Bailey.

INTRODUCTION

Alkali water, or water containing an unusual amount of soluble minerals, especially sulphates, is chiefly found in arid and semi-arid regions. Since the minerals are in the soil, the amount and kind of minerals contained in the water varies according to kind of soil, lay of land, kind of cultivation, manured or unmanured, drained or undrained, and climatic conditions. The amount and kind of minerals found in the examined and analyzed water from the different wells may be found in Tables I and II.

Many inquiries were received from localities in which alkali water is most prevalent, relative to the effects of its use in connection with the varied phases of the dairy industry. Experience of certain dairy farmers indicated that the milk from cows drinking alkali water did not coagulate normally for cheese-making purposes when rennet was added. Others refused to let the cows drink it, fearing that the cows and the milk might be injured, while other dairy farmers thought that washing the butter in alkali water would affect the butter. At the National Creamery Buttermakers' Convention held in St. Paul in 1907, a creamery operator from an adjoining state asked the question, "Is it injurious to wash butter in alkali water?" In this large audience composed of practical and scientific dairy and creamery men, no one was able to give a definite answer.

With a view of gaining information and obtaining data, giving at least partial light on these subjects, the herein reported experiments were conducted.

It was the intention of the investigators to first carry out the experiment on the part of the subject related to the effect of alkali water on dairy cows. This was deemed most urgent, first, because the dairy cow is basic to obtaining dairy products, and if certain effects are found on the cow. these same effects might have some bearing on the kind of products produced by the cow. Secondly, because certain localities were bothered with diseased cows. It was thought by some that drinking alkali water caused this disease.

To properly carry out this phase of the proposed experiment, suitable equipment, co-operation from the veterinary department and other necessary adjustments which could not then be made were essential. On these accounts the phase referring to dairy cows will be investigated during the coming year in co-operation with the veterinary department of this Experiment Station.

PLANS OF INVESTIGATIONS

The first point to ascertain was, whether alkali water could be obtained from a well which would yield a sufficient amount of water on which to feed not less than three cows during the whole year, and from which the quality of alkali water would vary as little as possible, and which contained water fairly representative as to average quality and strength of alkali water in the state and which is not stale and putrid. due to decayed organic matter.

In order to ascertain these things, examinations and analysis of the alkali water from various wells were made. A well in Midland was finally selected to supply the needed alkali water. This water was shipped in ten gallon milk cans by express. Several shipments were made by freight, but on account of the irregularity of arrival, and the length of time in transit, exposure to frost and other unfavorable conditions, this method of shipment was discontinued. Large quantities could not be shipped at any one time, as on standing it became brackish in taste and the cows objected to it. The water was fed to the cows while fresh from the well. It arrived in ten-can lots.

This water was fed to two lots of cows, number I, and number II. There were three cows in each lot. The cows were first put on a definite, normal ration, and received ordinary well water from the college well, Number 1. in Table I. Chemical analysis and other examinations, physical and bacteriological. were made of the milk and milk products under these normal conditions.

The cows in Lot I were fed soft water and those in Lot II received alkali water. The cows received all the water they wanted three times per day. The water drunk was carefully weighed. The quantity and quality of the grain ration and silage remained the same throughout the preliminary and experimental periods. The amount of hay was fed ad libitum, being the only part of the feed ration except water that was elastic in quantity.

Then Lot I, which was on soft water was changed to alkali water, and Lot II which was on alkali water was changed to soft water. A preliminary period of ten days was allowed between each period for the cows to get used to the change. No records except the amount of water drunk were kept during this interval.

Each experiment was carried on for a period of twenty-four days.

The cows in the two lots were carefully selected as to the average quantity and quality of milk, time of last freshening as well as time of future freshening. The cows in Lot I were in calf, while the cows in Lot II were barren.

The milk from the two lots of cows was carefully examined with a view of finding out whether there was any physical difference in the milks from the two lots of cows. Rennet tests were also made during the different periods.

Complete chemical analysis was made of the milk and its ash from each lot of cows, with a special view of finding out whether there was any difference in the amount of ash and kind of mineral constituents of the milk.

Likewise, butter and cheese were made from the milks of the two lots of cows. Examination as to quality and the various tests and analyses reported in the following tables were made.

The milk and milk products needed for these examinations were obtained and made during the last seven days of the twenty-four day experimental period. This was done so that the cows would show the fullest effect of the change of water.

ALKALI WATER SELECTED

The water from the Midland well number, thirteen (13), in Tables I and II, contained the highest per cent of total minerals and also the greatest quantity of sulphates. Considering this, the quantity of water that could be supplied, and the nearness of well to shipping point on direct line to Brookings, this water was selected for the experiments.

Although located in town, the water from this well was not used for live stock except in case of necessity. The owner of the well explained that it was too strongly alkali and was too dangerous to use for stock, although he had used it at times for the family cow. This water had a distinct saline, acrid and sharp taste. As far as could be determined, the water did not have any stale and other undesirable flavors due to decayed organic matter. The well was about 30 feet in depth and located on a side hill leading to a creek about 200 feet from the well.

At intervals the total minerals in the water were determined with a view of ascertaining the strength of same during the different seasons, and during the progress of the experiments. The total solids varied slightly.

The following table shows the composition of the water obtained from different wells.

TABLE NO. I.

Showing Amount and Kind of Minerals in Alkali Waters Examined from Different Wells

Analysis of Alkali Water

(Parts per million parts of water)

Laboratory No.	1	2	3	4	5	6	7
Locality	Brookin's	Mitch'll	Belle F'urche artesi'n	Belle F'urche bored	Brook-ings college	Fort Pierre Shallow	Presho
Kind of Well	tap water	90 ft dp	600 ft	20 feet	well		20 ft.
Surroundings	....	....	....	B. F. R. R'd'wtr Creek	....	Bottom Willow Creek	near Stony Butte
Taste	slightly unpleas't	thickish	mineral	none	sharp	slight	punge't
Odor	slight	none	none	none	slight	none	none
Turbidity	slight	bad	bad	clear	clear	qte bad	clear
Reaction	alkaline	alkaline	alkaline	alkaline	alkaline	alkaline	alkaline
Total Solids	741.000	846.000	869.000	718.000	487.000	2245.000	751.000
Loss on Ignition	186.000	202.000	138.000	210.000	184.000	283.000	132.000
Free Ammonia	0.226	....	0.664	0.093	0.020	0.064	0.112
Albuminoid Ammonia	0.110	....	0	0.013	0.020	0.084	0.040
Nitrates	0.060	0	0	3.600	0.200	0	0.300
Nitrites	0.003	0.005	0.002	0.008	0	0	0.008
Chlorine	4.290	19.210	13.300	26.770	6.470	161.130	10.460
Sulphates (SO4)	221.600	267.100	416.000	206.100	45.800	1093.900	229.800
Carbonates (CO3)	0	0	6.100	0	0	0	0
Bicarbonates (HCO3)	412.000	325.400	255.800	384.500	305.200	229.50.	370.900
Phosphates (PO4)	0	sl. tr.	0	sl. tr.	sl. tr	0	....
Silica (SiO2)	10.100	47.400	9.600	10.800	29.100	16.400	15.700
Iron and Aluminum	4.100	2.700	tr.	tr.	1.500	1.500	1.400
Calcium (Ca)	131.200	131.900	91.600	97.400	32.500	356.200	85.200
Magnesium (Mg)	51.500	39.100	36.000	58.400	46.500	71.700	16.600
Sodium (Na)	20.600	26.600	130.200	39.600	24.400	199.100	143.500
Potassium (K)	1.700	7.000	7.600	3.800	2.400	16.200	8.800
Total Bacteria	....	4.500	1.450	9.600	1,360	23,750	30,000

Laboratory No.	8	9	10	11	12	13	14
Locality	M Clure	Fort Pierre Bored	Philip	Sansarc	Philip	Mid-land	Miles-ville
Kind of Well	15 ft.	12 ft.	....	....	....	....	....
Surroundings	20 ft. fm dam	trib. to Ante-lope Cr.	....	....	....	....	....
Taste	very punge't	quite punge't	thicki'h & p'ng't	thicki'h & p'ng't	strong & briny	dist'nly salty	slight & saline
Odor	none	none	none	none	slight	none	none
Turbidity	slight	bad	slight	clear	very b'd	slight	clear
Reaction	alkaline	alkaline	alkaline	alkaline	alkaline	alkaline	alkaline
Total Solids	1623.000	3205.000	3154.000	2840.000	2573.000	7358.000	1908.000
Loss on Ignition	274.000	409.000	432.000	413.000	361.000	573.000	193.000
Free Ammonia	0.014	1.816	0.044	0.304	0.362	0.362	0.010
Albuminoid Ammonia	0.036	0	0.010	0.076	0.114	0.248	0.018
Nitrates	0	tr.	tr.	sl. tr.	0	0	0
Nitrites	0.007	0.007	0.008	0.013	0.011	sl. tr.	0.004
Chlorine	10.360	21.210	43.330	14.640	18.230	311.250	42.690
Sulphates (SO4)	721.800	1726.900	1639.600	1362.700	1429.300	3887.000	1010.30
Carbonates (CO3)	0	0	0	0	0	0	0
Bicarbonates (HCO3)	413.900	456.300	310.400	586.800	308.100	668.300	252.100
Phosphates (PO4)	....	....	....	....	....	....	....
Silica (SiO2)	21.000	10.000	37.800	12.900	11.100	13.300	32.000
Iron and Aluminum	2.000	4.900	4.700	5.800	3.700	7.000	0
Calcium (Ca)	225.400	416.200	256.000	273.800	334.800	427.800	193.000
Magnesium (Mg)	43.400	85.000	121.000	93.400	107.500	167.600	65.800
Sodium (Na)	195.200	350.300	456.300	431.300	236.7000	1577.600	264.600
Potassium (K)	20.000	15.000	11.500	11.600	8.500	28.500	10.500
Total Bacteria	8.800	16.200	23.000	50,000	1.650	370.000	8.500

The exact combination in which these minerals exist in the water is difficult to state. The following table shows the hypothetical combination of minerals in the water calculated from data in previous Table No. I. and in accordance with rules on Page seventeen (17) of Bulletin Number Ninety-one (91), Bureau of Chemistry, United States Department of Agriculture.

TABLE NO. 11.

Showing Hypothetical Combination in which Minerals Exists in Alkali Waters

(Parts per million parts of water)

Number of Well	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Ammonium Chloride	0.8	....	2.5	0.4.	0.1	0.2	0.4	0.2	7.0	0.2	1.1	1.4	1.4	.....
Potassium Chloride	3.2	13.5	14.5	7.2	4.6	30.9	16.8	21.7	28.6	21.9	22.1	16.2	51.3	20.0
Potassium Sulphate	.....	....	....	....	....	....	.....	19.2	......	......	......	.....	......	.....
Sodium Chloride	3.8	21.5	7.8	38.1	6.9	241.2	3.6	....	4.8	51.1	5.6	15.8	469.2	51.7
Sodium Sulphate	58.7	56.5	392.6	57.8	66.1	314.5	339.9	603.0	1076.0	1343.7	1325.3	712.0	4302.2	750.8
Sodium Nitrate	0.4	....	....	21.8	1.2	....	1.8	....	......	......	......	.....	......	.....
Sodium Bicarbonate	.....	....	....	....	....	....	116.1	....	......	......	......	.....	......	.....
Magnesium Sulphate	227.1	193.7	178.0	205.1	1.4	354.6	.....	214.6	410.3	589.3	486.6	531.6	828.8	325.4
Magnesium Bicarbonate	55.9	....	....	122.0	277.5	....	99.7	....	......	......	......	.....	......	.....
Calcium Sulphate	.....	104.3	11.8	....	....	834.0	.....	183.5	935.5	352.0	108.7	726.9	439.6	325.1
Calcium Bicarbonate	485.6	416.4	338.5	373.8	98.2	305.0	270.2	550.1	606.2	412.5	779.6	409.5	887.9	335.1
Calcium Carbonate	.....	....	10.2	....	....	....	.....	....	......	......	......	.....	......	.....
Ferrous Bicarbonate	.....	8.6	....	....	....	....	.....	....	......	......	......	.....	......	.....
Ferric Oxide	5.8	....	....	....	2.1	2.1	2.1	3.0	7.3	7.0	8.6	5.5	10.4	.....
Calcium Silicate	17.8	....	2.9	18.6	23.8	28.9	27.7	37.0	17.6	66.7	22.8	19.6	23.5	56.4
Calcium Oxide	7.7	....	....	....	....	53.8	13.6	37.0	41.1	48.7	60.9	33.7	109.0	14.8
Silica	.....	47.4	8.1	1.1	16.8	....	.....	....	......	......	......	.....	......	.....

MILK FROM COWS RECEIVING ALKALI WATER

In addition to the regular examination of the milk made by the various members of the Dairy Department, a number of dairy students were requested to pass judgment on the comparative quality of milk from the two lots of cows receiving soft and alkali water, respectively. The results of their judgment are as follows:

Total number of students examining the milk, forty (40).

Number of students pronouncing the milk from cows receiving the alkali water, the best, twenty-one (21).

Number of students pronouncing the milk from cows receiving soft water, the best, twelve (12).

Number of students having no preference, seven (7).

The students did not know from which lot of cows the milk came.

The difference in appearance, flavor odor, and other physical characteristics of the two kinds of milks was so slight that it could not be discerned by the ordinary keenness of sense, smell, taste and sight.

The milk was carefully examined as to flavor and aroma throughout the experiments, and no definite difference could be found, traceable to the alkali water.

The reports or complaints made by some dairy farmers as to the probable, undesirable effect of alkali water on the flavor and properties of the milk, evidently should be accounted for in other ways than by the alkaline condition or excessive amount of minerals in the water.

It has been amply demonstrated that stale and putrid water will impart undesirable flavor and odors to milk when drunk by the cow. Some alkali wells contain water which is not only rich in soluble minerals, but which is also brackish and almost putrid in taste and smell. When such water is drunk by the dairy cow, her milk will not be clean of flavor and smell. This undesirable quality of milk can not be laid to the alkali or minerals in the water, but rather to the decayed organic matter so common in alkali water. In the semi-arid regions, especially in the newly settled localities, shallow wells are common, and the water from such wells many times contains too much organic matter.

Alkali water evidently has the ability of dissolving more organic matter than will ordinary well water. Especially is this true if the water contains very much sodium carbonate (Na2 CO3) or what is known as black alkali. This substance derives its name from the fact that it has the ability to dissolve organic matter. From the analyses made, it appears that this is substantiated. The greater the amount of minerals, the more organic matter or loss on ignition. The loss on ignition may also be due in part to the decomposition of carbonates.

Whether or not the germs have the ability to decompose this organic matter in alkali water so rapidly as in ordinary water is yet a question. At any rate, a large proportion of the alkali wells examined contained water which had a bad odor and taste, not due to minerals, but to decayed organic matter. Special precautions were taken to select alkali water from which organic matter was excluded as much as possible for use in these experiments.

COMPOSITION OF MILK

Chemical analyses were made of the milk from all the cows and also of the milk ash. The samples of milk for chemical analysis were composite samples carefully taken as to average quality and proportionate in size to the amount of milk given by each cow. The taking of these composite samples extended over a period of seven consecutive days, and they were obtained during the latter part of the twenty-four day experimental periods.

The following table shows the composition of milk and milk ash from the two lots of cows fed on normal, soft, and alkali water.

TABLE III.

Showing Composition of Milk and its Ash, from Cows Drinking Alkali and Soft Water

Preliminary period under normal conditions

Lot	No. of Cow	Composition of Milk (per cent). Water	Fat	Protein	Casein	Albumen	Sugar	Ash	Constituents of Ash (parts per million of milk). Chlorine	Sulphates	Phosphates	Calcium	Magnesium	Sodium	Potassium
I College well	1	86.44	4.17	3.53	2.79	0.74	5.11	0.749	760.0	225.0	3040.0	1284.0	118.0	382.0	1435.0
	2	86.34	4.03	3.83	2.96	0.87	5.00	0.804	770.0	233.0	3288.0	1330.0	108.0	441.0	1495.0
	3	86.94	4.00	3.24	2.54	0.70	5.05	0.773	802.0	169.0	3189.0	1293.0	110.0	423.0	1464.0
Average	.	86.57	4.07	3.53	2.76	0.77	5.05	0.775	777.0	209.0	3172.0	1302.0	112.0	415.0	1465.0
II College Well	4	87.43	3.64	3.41	2.68	0.73	4.73	0.791	863.0	228.0	3556.0	1085.0	123.0	379.0	1661.0
	5	87.29	3.80	3.36	2.66	0.70	4.82	0.725	996.0	220.0	2441.0	1127.0	115.0	484.0	1385.0
	6	85.77	4.49	3.77	2.95	0.82	5.20	0.768	703.0	208.0	3315.0	1393.0	125.0	375.0	1207.0
Average	.	86.83	3.98	3.51	2.76	0.75	4.92	0.761	854.0	219.0	3104.0	1202.0	121.0	413.0	1418.0
Experimental Period I															
I On soft Water	1	86.25	4.27	3.76	2.99	0.77	4.94	0.775	749.0	224.0	3146.0	1255.0	122.0	443.0	1380.0
	2	86.04	4.19	3.96	3.16	0.80	5.03	0.779	754.0	217.0	3289.0	1298.0	112.0	449.0	1523.0
	3	86.77	4.04	3.35	2.71	0.64	5.05	0.788	774.0	198.0	3310.0	1316.0	109.0	636.0	1448.0
Average	.	86.35	4.17	3.69	2.95	0.74	5.01	0.781	759.0	213.0	3248.0	1290.0	114.0	509.0	1450.0
II On Alk'i Water	4	87.48	3.55	3.34	2.63	0.71	4.85	0.783	804.0	281.0	2888.0	1086.0	141.0	455.0	1741.0
	5	87.31	3.78	3.46	2.71	0.75	4.74	0.708	1032.0	213.0	2402.0	1099.0	98.0	656.0	1334.0
	6	85.34	4.88	3.93	2.90	1.03	5.09	0.758	756.0	256.0	3153.0	1393.0	111.0	510.0	1191.0
Average	.	86.71	4.07	3.58	2.75	0.83	4.89	0.750	864.0	250.0	2814.0	1193.0	114.0	540.0	1422.0
Experimental Period II.															
I On Alk'l Water	1	85.96	4.35	3.74	2.92	0.82	5.18	0.768	713.0	237.0	3194.0	1286.0	117.0	435.0	1440.0
	2	85.96	4.48	3.97	3.07	0.90	4.82	0.771	775.0	264.0	3124.0	1205.0	118.0	427.0	1508.0
	3	86.67	4.36	3.22	2.53	0.69	5.00	0.753	833.0	206.0	3114.0	1215.0	115.0	496.0	1440.0
Average	.	86.20	4.40	3.64	2.84	0.80	5.00	0.764	774.0	236.0	3144.0	1235.0	117.0	453.0	1463.0
II On Soft Water	4	86.96	3.90	3.54	2.87	0.67	4.83	0.773	852.0	211.0	2974.0	1139.0	146.0	551.0	1697.0
	5	86.70	4.12	3.69	3.05	0.64	4.75	0.735	1191.0	225.0	2492.0	1239.0	123.0	672.0	1157.0
	6	85.38	4.80	4.08	3.13	0.95	4.99	0.749	768.0	185.0	3184.0	1332.0	132.0	438.0	1261.0
Average	.	86.35	4.27	3.77	3.02	0.75	4.86	0.752	937.0	207.0	2884.0	1237.0	134.0	554.0	1372.0

TOTAL PER CENT MILK ASH

The percentage composition of the milk yielded by the same lot of cows receiving the different kinds of water in the different periods is normal, and varies so little that the variation is no greater than such as is within the range allowed for experimental variation.

From the table it will be noted that the total per cent of mineral or ash is quite uniform, no matter what kind of water drunk by the cow. This is true when the same individual cows in the different experimental periods at different times are compared, with the other individuals in the other lot at the same time. For instance: the milk from cow No. 1 in Lot No. I, receiving soft water, contained 0.775 per cent ash. In the second experimental period when this same cow received alkali water the milk contained 0.768 per cent of ash, an almost identical per cent. This same thing holds true with each of the other cows also when similiarly compared.

When the individual cows in the different lots at the same time are compared, there is again a very slight difference in the per cent of minerals or ash in the milk from the two lots of cows. For instance: the milk from cow No. 1 in the first experimental period contained 0.775 per cent ash, while the milk from cow No. 4 at the same time receiving alkali water contained 0.783 per cent ash.

The average per cent ash from the three cows in each lot show similiar results when compared. The average per cent ash in milk of Lot I, is 0.781, while receiving soft water, and the average of the same lot while on alkali water is 0.764 per cent. When one lot is compared with the other at the same time in the first experimental period, Lot I drinking soft water yielded milk containing on an average 0.781 per cent ash, while the average per cent ash contained in milk from cows in Lot II on alkali water is 0.750. In the second experimental period when the kind of water was changed, the milk from cows in Lot I while receiving alkali water, contained the average of 0.764 per cent, and the milk from Lot II, receiving soft water, contained 0.752 per cent of total ash.

Although the cows receiving alkali water consumed about one-half pound more of the different soluble minerals per day, this did not have the effect of increasing the total per cent minerals or ash of the milk. Undoubtedly the cow's system is so constructed that in this respect it maintains a certain constancy in the total percentage of minerals or ash in the milk. Just where and how the excess of minerals taken into the digestive tract of the cow are disposed of, and what the possible effect on the secretory and vital organs of the cow are, is now being investigated.

MILK ASH CONSTITUENTS

The results shown in Table III and Table IV as to the milk ash constituents indicate that some of the component parts of the ash may be slightly varied in per cent as well as total amount, by feeding unusual quantities of certain water soluble minerals to the cow. This variation however, is slight.

TABLE IV.

Comparison of the Average Composition of Milk and Ash from the Same Lot Drinking the Different Kinds of Water During the Three Successive 24 Day Periods

Lot	Kind of Water	Per Cent Composition of Milk							Constituents of Ash. (parts per million of milk).						
		Water	Fat	Protein	Casein	Albumen	Sugar	Ash	Cl. Chlorine	SO4 Sulphates	PO4 Phosphates	Ca. Calcium	Mg. Magnesium	Na. Sodium	K. Potassium
	Col. Well	86.57	4.07	3.53	2.76	0.77	5.05	0.775	777.0	209.0	3172.0	1302.0	112.0	415.0	1465.0
I	Soft	86.35	4.17	3.69	2.95	0.74	5.01	0.781	759.0	213.0	3248.0	1290.0	114.0	509.0	1450.0
	Alkali	86.20	4.40	3.64	2.84	0.80	5.00	0.764	774.0	236.0	3144.0	1235.0	117.0	453.0	1463.0
	Col. Well	86.83	3.98	3.51	2.76	0.75	4.92	0.761	854.0	219.0	3104.0	1202.0	121.0	413.0	1418.0
II	Alkali	86.71	4.07	3.58	2.75	0.83	4.89	0.750	864.0	250.0	2814.0	1193.0	114.0	540.0	1422.0
	Soft	86.35	4.27	3.77	3.02	0.75	4.86	0.752	937.0	207.0	2884.0	1237.0	134.0	554.0	1372.0

From these experiments it seems safe to state that the variation in the composition of the milk ash due to the consumption of a mixture of unusual quantities of soluble minerals, is not so great as to cause any undesirable or other characteristics different from those that are natural to normal milk.

As shown in Table 6 the cows on alkali water received on an average about one-half pound of mixed soluble minerals (composition of which is shown in Table II) per day more than did those receiving soft water. Yet there is but slight effect upon the component parts of the ash of milk.

Different investigaters have experimented with differen minerals and their effect on the milk when fed to cows:

J. Neuman* reports that he fed calcium phosphate to three cows first during a period of less than two weeks without any results. Then he fed one hundred grams of calcium phosphate daily in the regular ration to each cow during about five weeks. The calcium increased from 1.4791 grams to 1.5916 grams, and the phosphoric acid from 1.9598 grams to 2 1323 grams per one thousand grams of milk. The increase occured in the latter part of the five week period.

E. Hess & Schaeffer† came to similiar conclusions, that by feeding fifty grams of calcium phosphate per day to the cow, the phosphoric acid of the milk ash was increased from three to four per cent.

E. Hess. Schaeffer. and M. Lang§ also found that Glaubers' salt, (Na_2SO_4) forty to sixty grams per day, caused a peculiar acid taste to the milk. It also caused a decrease in the coagulability of the milk with rennet.

In this connection it should be stated that calcium phosphate is present in largest quantities of any of the milk ash constituents. It is therefore natural to expect a greater variation in this than in any of the other minerals of the milk ash.

In considering the above reported variation in the calcium phosphate, one should keep in mind that the single minerals were fed in excess. Different results might have been obtained had the same amount of calcium phosphate been fed in connection with a mixture of excessive amounts of other mine-

*Milch. Ztg. No. 43, p. 701. Year 1893. Abs. E. S. R. Vol. 5, p. 639.
†Landw. Jahrb. d. Schweiz. 1891. p. 76. Abs. E. S. R. Vol. 3, p. 744.
§Landw. Jahrb. Schweiz. 7, (1903) pp. 210-229.

rals. The mixture of minerals may cause chemical changes, cleavages and synthetic products that would affect the milk differently than if only a single mineral was increased.

C. Schulte & Bauminghaus* studied the influence and disposition of some mineral substances fed to milch cows. A study was made of the effect of feeding calcium hydroxide, sodium chloride, iron acetate and calcium phosphate. None of these substances affected apparently the yield of milk or its fat content. Neither was the total ash appreciably affected. Calcium hydroxide and calcium phosphate increased slightly the percentage of calcium in the ash. There was no increase in the phosphoric acid or iron due to the feeding of these substances.

●. Jensen† fed lactate of iron, calcium sulphate, di-sodium phosphate. di-calcium phosphate, di-magnesium phosphate, potassium chloride, sodium chloride and potassium nitrate. Potassium nitrate was detected in the milk six hours after ingestion, but not after eighteen hours. The other remaining substances did not affect the yield and composition of milk, only the coagulability of the milk with rennet.

G. Von Wendt‡ added various salts to the rations of milch cows and studied their effect upon the chemical composition of the milk. Some of the author's conclusions are as follows:

Common salt, carbonate of lime, sodium phosphate, magnesium bromide, and calcium glycero-phosphate appeared to have no effect on the composition of the milk. Acid calcium phosphate appears at times to influence favorably the fat and to increase the relative amount of original calcium. The percentage of albumen does not increase toward the end of the lactation period. Phosphorous, total nitrogen and casein. are the least variable, while chlorine, potassium and albumen are the most variable of the milk constituents.

C. Moi§ experimented with two cows with a view of finding out whether the percentage of iron in the milk could be in-

*Mitt. Landw. Inst. Univ. Breslau No. 2, 1902, No. 1, p. 25. Abs. E. S. R. Vol. 15, p. 311.

†Landw. Zahrb. Schweiz. 18 (1904) No. 10. p. 471. Abst. E. S. R. Vol. 16, p. 1010.

‡Skand. Arch. Physiol. 21 (1908). No. 2-3. pp. 89-145, Mitt. Landw. Inst. Leipzig, 1908. No. 9,—. 127. Abst. E. S. R. 20, pp. 1177.

§Ztschr. Uttersuch. Nahr. u. Genussmtl., 19 (1910) No. 1. p. 21, Abst. E. S. R. 22, p. 678.

creased. The ration given the cow in a large measure was composed of a proprietary feed that contained a large percentage of iron. It was claimed that this would raise the percentage of iron in the milk. This claim was not sustained by the experiment.

In these experiments, the constituent parts of the ash which show evidence of varying most in quantity with the amount taken into the system are the sulphates and potassium. Lot I. on soft water on an average, yielded milk which contained 213 parts of sulphate per million parts of milk. The same lot on alkali water yielded milk containing 236 parts of sulphates per million parts of milk.

This same thing holds true with the cows of Lot II. While they received soft water their milk averaged 207 parts of sulphates per million parts of milk. When receiving alkali water the sulphates increased to 250 parts per million parts of milk.

The increase in sulphates is fully as marked when Lot I is compared with Lot II during the same time. The cows in Lot I receiving soft water yielded milk containing 213 parts of sulphates per million: while those in Lot II on alkali water during the same time yielded milk that contained 250 parts of sulphates per million of milk. When the cows in Lot I received alkali water their milk contained 236 parts of sulphates per million, while the milk from the cows on soft water in Lot II at the same time dropped to 207 parts of sulphates per million parts of milk.

Considering the large amounts of sulphates taken into the digestive tract in the form of water, this increase of sulphates in the milk is very slight.

Since the sulphates in the alkali water occur in combination with some mineral, chiefly sodium, it appears that there should at the same time be an increase in these substances in the milk ash. This is not shown in the results. Considering the properties of sodium and the combinations in which it occurs with the sulphate, the corresponding increase of the sodium could at the most be only approximately one-fourth as much as that of the sulphates.

The mineral that shows an increase due to the effect of drinking alkail water is potassium. Although a less quantity is present in the alkali water it is probable that the potassium compounds can more easily pass through the various processes of absorption and assimilation into the milk without being eliminated than can any other of the alkali water mineral compounds. In this connection one should keep in mind that potassium ranks second highest in quantity in the milk ash. The phosphate is the only one exceeding it in quantity.

TABLE V.

Comparison of the Average Amounts of Milk and Ash Constituents from the Same L of Cows Drinking Different Kinds of Water During the Three Successive 24 Day Periods, Pounds.

Lot	Kind of Water	Dates of Periods	Total amt of milk	Pounds of Milk Constituents Produced in 24 days. Water	Fat	Protein	Casein	Albumen	Sugar	Ash	Pounds of Ash Constituents Produced in 24 days Chlorine	Sulphates	Phosphates	Calcium	Magnesium	Sodium	Potassium
I	College well	Nov. 20 Dec. 14	497.5 lbs	430.69	20.25	17.56	13.73	3.83	25.13	3.86	0.387	0.104	1.583	**0.648**	**0.056**	**0.206**	**0.729**
I	Soft	Dec. 18 Jan. 11	457.3 lbs	394.88	19.07	16.87	13.49	3.38	22.91	3.57	0.347	0.097	1.485	**0.590**	**0.052**	**0.233**	**0.663**
I	Alkali	Jan. 15 Feb. 8	430.5 lbs	371.09	18.94	15.67	12.22	3.44	21.53	3.29	0.333	0.102	1.353	**0.532**	**0.050**	**0.195**	**0.630**
II	College Well	Nov. 20 Dec. 14	411.1 lbs	356.96	16.36	14.43	11.35	3.08	20.23	3.13	0.351	0.090	1.276	**0.494**	**0.050**	**0.170**	**0.583**
II	Alkali	Dec. 18 Jan. 11	390.3 lbs	338.43	15.89	13.97	10.73	3.24	19.09	2.93	0.337	0.098	1.098	**0.466**	**0.044**	**0.211**	**0.556**
II	Soft	Jan. 15 Feb. 8	324.6 lbs	280.29	13.86	12.24	9.80	2.44	15.78	2.44	0.304	0.067	0.936	**0.402**	**0.043**	**0.180**	**0.445**

TABLE VI.

Pounds of Water and Minerals Consumed in the Water During the 24 Day Periods by Each Lot of Cows.

Lot	Period	Kind of Water Drank	Amt. of water drank	Total Min'ls Cons'd in water	Lbs. of Mineral constituents consumed in water in 24 days								
					Chlorine	Sulphates	Bicarbonates	Silica	Iron & Aluminum	Calcium	Magnesium	Sodium	Potassium
I	Prelim	College well	6735	3.326	0.044	0.308	2.056	0.196	0.010	0.219	0.313	0.164	0.016
	1st Exp.	Soft	6254	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	2nd Exp.	Alkali	5663	40.142	1.763	22.012	3.785	0.075	0.040	2.423	0.949	8.934	0.161
II	Prelim.	College well	5616	2.772	0.036	0.257	1.714	0.163	0.008	0.183	0.261	0.137	0.013
	1st Exp.	Alkali	4816	34.292	1.499	18.720	3.219	0.064	0.034	2.060	0.807	7.598	0.137
	2nd Exp	Soft	4921	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE VII

Comparison of the Average Amount of Milk and Ash Constituents from the Two Lots of Cows Drinking Different Kinds of Water at the Same Time During the Three Succesive 24 Day Periods.

Period	Lot	Kind of Water	Total Amt of Milk	Pounds of Milk Constituents Produced							Pounds of Milk-ash Constituents produced in 24 days						
				Water	Fat	Protein	Casein	Albumen	Sugar	Ash	Chlorine	Sulphates	Phosphates	Calcium	Magnesium	Sodium	Potassium
Preliminary Nov 20.	I	Col. well	497.5	430.69	20.25	17.56	13.73	3.83	25.13	3.86	0.387	0.104	1.583	0.648	0.056	0.206	0.729
Dec. 14	II	Col. well	411.1	356.96	16.36	14.43	11.35	3.08	20.23	3.13	0.351	0.090	1.276	0.494	0.050	0.170	0.583
1st Exper Dec. 18	I	Soft	457.3	394.88	19.07	16.87	13.49	3.38	22.91	3.57	0.347	0.097	1.485	0.590	0.052	0.233	0.633
Jan. 11	II	Alkali	390.3	338.43	15.89	13.97	10.73	3.24	19.09	2.93	0.337	0.098	1.098	0.466	0.044	0.211	0.556
2nd Exper Feb. 8	I	Alkali	430.5	371.09	18.94	15.67	12.22	3.44	21.53	3.29	0.333	0.102	1.353	0.532	0.050	0.195	0.630
Jan. 15	II	Soft	324.6	280.29	13.86	12.24	9.80	2.44	15.78	2.44	0.304	0.067	0.936	0.402	0.043	0.180	0.445

COAGULABILITY OF MILK WITH RENNET

At the same time that the composite samples of milk were obtained for chemical analysis. larger samples were taken from each cow's milk for the purpose of testing the effect of alkali water on the coagulability of the milk.

These samples were taken and rennet tests made at once after milking. The Marschall rennet test was used. The same kind of rennet was used throughout for the various tests. Otherwise rennets having different strengths might have caused an error in the results for comparison. Efforts were made to use the same amount of rennet for each test, thus having the difference show only in the time or number of spaces on the test required for coagulation. On account of the limited number of spaces on the test, it was found necessary to vary the amount of rennet used.

TABLE VIII

Effect of Rennet Test of Milk From Cows Drinking Soft and Alkali Water.

		Preliminary Period Nov. 20 to Dec. 14					Experimental Period Dec. 18 to Jan. 11.					Experimental Period Jan. 15 to Feb. 8				
	No of Cow	Water Drank	Rennet Used c. c.	Spaces to coagulate	Time to coagulate	Per cent Acidity	Water Drank	Rennet Used c. c.	Spaces to coagulate	Time to coagulate	Per cent Acidity	Water Drank	Rennet Used c. c.	Spaces to coagulate	Time to coagulate	Per cent Acidity
Lot I	1	College Well	1	4 7-8	4.00 min	.16	Soft	2	3 3-8	2.90 min	.16	Alkali	2	3 1-8	2.75 min	.16
	2		1	4 1-2	5.10 min	.17		2	4	3.65 min	.17		2	4 3-8	3.75 min	.17
	3		1	4 1-4	4.65 min	.15		10	3 7-8	3.25 min	.16		2	4 1-8	3.50 min	.15
Lot II	4	College Well	5	6 3-8	6.85 min	.14	Alkali	10	5 1-4	4.90 min	.14	Soft	10	3 3-8	3.65 min	.14
	5		5	2 1 4	2.35 min	.13		2	2 1-2	2.25 min	.13		10	1 1-2	1.35 min	.12
	6		1	3 1 3	3.40 min	.17		2	3	2.60 min	.16		2	3	2.75 min	.16

From the table above it will be seen that there is considerable difference in the coagulability of the milk from the different cows. This difference does not seem to vary with the kind of water drunk and the amount of minerals taken into the body, but rather according to the individuality of the cow and advance in gestation period.

As formerly stated the cows in Lot I were barren or not in calf, while the three cows in Lot II were about five months along in the gestation period at the time of the second experimental period.

This fact may have a bearing on the greater quantity of rennet needed for coagulating a given amount of milk. It seems probable that some of the calcium is utilized by the developing foetus, which otherwise should go to the milk. This appears to bear out the theory that the blood in the individual cow is capable of assimilating only so much of the necessary minerals. Certainly there was more than enough calcium present in the water and feed to satisfy the demand of the foetus and milk both, if the circulatory system could have absorbed and assimilated it.

The milk from cows Number four and five in Lot II contained considerably the least calcium, as may be seen from Table III, and it was this milk which required the most rennet for coagulation and which had the softest coagulum. It appears to be quite evident, that the more calcium in the milk, the less rennet is necessary for coagulation and the firmer the curd. The less calcium in the milk the more rennet was necessary and the softer was the coagulum. In fact, after a certain point an increase in the rennet did not hasten the coagulation of the milk in proportion to the increase of the rennet. It seems, as though only so much rennet is necessary, and when this necessary amount has been added, an increase of rennet over this amount hastens the coagulation of the milk but little. From the above results it appears that a cow well advanced in the gestation period is likely to yield milk low in calcium and therefore less coagulable.

If a cow is already receiving a normal ration containing normal quantities of the various minerals, especially calcium phosphate, an addition of excessive amounts of minerals, such as is contained in alkali water does not affect the coagulability of milk when rennet is added.

In this connection it is also interesting to note that the acidity of the milk from these two cows is lower than that of the others. The acidity of the milks was determined at once after milking, so the acid reaction cannot be due to any developed acid in the milk, but evidently is due principally to the acid calcium phosphate, partially if not wholly combined with the casein. The less acidity therefore corroborates the less calcium found by analysis.

EFFECT OF ALKALI WATER ON BUTTER

Butter was manufactured from the milk of each of the two lots of cows, first when the cows were on normal ration and drinking the normal well water. This was done with a view of getting a rating on the quality produced before the cows in the two lots were changed to soft and alkali water respectively.

Likewise butter was made from the milk of the cows in each of the two lots, while drinking alkali and soft water.

The butter was judged by J. C. Joslin, Federal Dairy Expert, stationed in the Chicago butter market, and by C. Larsen. The tubs of butter were numbered and their source was unknown to the judges. C. Larsen scored the butter when fresh, and J. C. Joslin when it was about a week old. The shipping of the butter from Brookings to Chicago delayed the scoring about one week.

The average results are shown in the following table:

TABLE IX.

Butter from Cows Drinking Alkali Water vs. Butter from Cows Drinking Soft Water.

Test No	No. of Lot of Cows	Water Drank	C. Larsen Score by	Score by J. C. Joslin	Average of both scores	Acidity
I	1	College Well	92	92	92	1.8
	2	College Well	92½	93	92	2.0
II	1	Soft	94	93	93½	1.8
	2	Alkali	93	92	92½	1.8
III	2	Soft	92	92	92	2.0
	1	Alkali	91	92	91½	2.0

The butters from the two lots of cows were made under like conditions through the various processes of manufacture.

From the results shown in the table there is very little difference in the quality of the butter made from the milk produced by the cows receiving alkali and soft water. This was rather to be expected, inasmuch as alkali water had been found not to affect the quality of the milk. Inasmuch as the quality of the butter corroborates what has already been found in respect to the effect of alkali water on the quality of the milk it was deemed unnecessary to repeat this experiment more than three times.

WASHING BUTTER IN ALKALI WATER

A certain amount of cream was put in a vat and thoroughly mixed. This cream was prepared for churning in the usual way. The details of manufacture shall not be given here, as they are alike for each experiment and therefore do not affect comparisons. This cream was divided into two equal lots and churned separately. The butter from one lot, or one half of the cream, was washed in water from the college well, or in freshly cooled condensed steam, as indicated in the table. The butter from the other half was washed in alkali water from the various alkali wells, which is also indicated in table X.

The alkali water used for washing the butter had a distinct sharp and slightly saline taste, but otherwise it had no real offensive smell and taste. The washing of the butter was done in the usual way by first rinsing the butter and draining it. Then it was thoroughly washed in the particular kind of water. Equal amounts of water and washings were used in washing the butters to be compared. In two experiments the butter was not salted.

The unsalted butter really afforded the best opportunity for finding the effect of alkali water on the quality of the butter. This is also the only butter in which the alkali water flavor could at all be detected. It will be noticed that after the first week the butter washed in alkali water scored a trifle lower than did the butter washed in the regular well water and condensed steam. The average difference at the end of the first week in favor of the butter not washed in alkali water is one point. This difference is however small, but inasmuch as it was continuously noticed, the difference must be due to the alkali water, and cannot be considered within the limit of error usually allowed in judging butter. In the salted butter neither the local or the Chicago judge could find any difference in the quality due to the alkali water.

TABLE X.

Effect of Washing Butter with Alkali Water

Test No.	Kind of Water Used	Whether Salted	SCORE AND ACIDITY OF BUTTER WHEN: Fresh, Score	Fresh, Acidity	2 weeks, Score	2 weeks, Acidity	4 weeks, Score	4 weeks, Acidity	6 weeks, Score	6 weeks, Acidity	ANALYSIS OF BUTTER: Fat	Water	Casein	Ash	Constituents of Ash per million parts butter: Cl	SO4	PO4	Ca	Mg	Na	K
I	City	Salted	92	1.6	...	....	...	....	...	...	83.82	13.83	0.96	1.39	8297.5	159.1	555.4	156.6	28.2	6732.2	122.1
	Alk. No. 9	Salted	92	1.6	...	....	...	....	...	...	84.25	13.49	0.98	1.28	7145.5	102.8	553.9	171.4	40.7	5776.4	121.6
II	Condensed Steam	Un-Salted	92	1.9	92	2.2	88	2.6	80	3.4	85.99	13.17	0.77	0.075	11.2	5.8	456.1	121.9	23.2	50.7	111.5
	Alk. No. 13	Un-Salted	92½	1.8	91	2.15	89	2.6	80	3.4	85.80	13.35	0.74	0.113	3.3	141.5	456.1	169.1	23.6	174.4	118.1
III	College well	Un-Salted	93	1.8	93	2.0	90	2.6	85	3.1	84.95	14.00	0.96	0.050	12.1	5.0	541.5	166.3	22.7	68.9	113.8
	Alk. No. 10	Un-Salted	93½	1.8	92	2.0	89	2.6	85	3.1	85.07	13.96	0.88	0.095	13.9	11.0	471.1	128.1	20.4	105.4	121.2
IV	College well	Salted	92	1.8	91	2.4	88	2.5	89	3.0	82.98	12.94	0.84	3.21	17921.3	40.3	521.5	141.3	23.0	12097.3	159.7
	Alk. No. 14	Salted	92	1.8	92	2.4	86	2.5	86	3.2	82.61	13.32	0.96	3.11	16970.1	59.7	518.7	137.5	21.3	11233.2	148.9
V	College well	Salted	90	2.0	89	2.8	87	2.9	87	3.0	81.39	14.00	0.91	3.70	21400.2	70.8	547.3	162.7	26.1	14513.4	36.5
	Alk. No. 12	Salted	90	2.0	90	2.8	88	2.8	88	2.9	82.40	13.26	0.92	3.42	20016.2	87.0	519.0	162.7	25.8	13913.2	105.2
VI	College well	Salted	93	2.6	90*	....	...	....	...	...	.....	.....	....	....	......	.....	.....	.....	....	......	.....
	Alk. No. 13	Salted	92½	2.5	89*	Shipped to Chicago to be judged					.....	.....	....	....	......	.....	.....	.....	....	......	.....
VII	College well	Salted	94	2.2	91*	....	...	....	...	...	.....	.....	....	....	......	.....	.....	.....	....	......	.....
	Alk. No. 13	Salted	94	2.0	91*	....	...	....	...	...	.....	.....	....	....	......	.....	.....	.....	....	......	.....
	Average	Normal Water	92 4-14	1.99	91¼	2.35	88¼	2.65	85¼	3.13	.....	.....	....	....	......	.....	.....	.....	....	......	.....
		Alkali Water	92 5-14	1.93	91¼	2.34	88	2.63	84¾	3.15	.....	.....	....	....	......	.....	.....	.....	....	......	.....

*Scores by J. C. Joslin

The question has often been raised: Do certain minerals contained in the wash-water go into chemical combinations with lactic acid and probably other decomposition products already in the butter when made, or developed in the butter on standing; and thereby produce undesirable effects on the quality and keeping property of the butter.

Theoretically, the soluble lime or calcium carbonate, lime or calcium sulphate may possibly under favorable conditions unite with lactic acid to form their salts and thereby produce a sourish flavor in the butter. From a practical standpoint this theory was not found to be of any importance. It is possible that if the lactic acid is not properly washed out of the butter that the above mentioned principle would affect the quality of the butter.

The alkali water used in these experiments contained very little iron and magnesium. Iron and magnesium are known to combine with lactic acid to form the respective lactates, and each substance imparts a bitter flavor to butter. If butter is thoroughly washed while in granulated condition, the acid of butter is reduced to its minimum, and if the wash water does not contain abnormally large amounts of these minerals, as usually it does not, and if the butter is kept in cold storage at low temperature, which reduces chemical changes, there should not be enough changes deleterious to butter due to the soluble minerals in the alkali wash-water.

The great danger to butter from wash-water comes not so much from inorganic impurities as it does from organic substances and the presence of undesirable organisms. The former under favorable conditions may undergo chemical changes; but the latter (organic matter) in the presence of bacteria undergoes both fermentative and chemical changes deleterious to butter. Such putrid water may affect the smell, taste and even the healthfulness of dairy products. Ferments associated with organic impurities in wash-water are known to belong to the groups of bacteria that decompose constituents, especially the proteids of butter.

At the same time that the butter washed in the different kinds of wash-water was judged at Brookings, the acidity was also determined. The acidities were determined as a check on the judges to determine the comparative keeping properties of butter washed in alkali water, versus that washed in other kinds of water. The acid tests corroborated the results of the judges that alkali water if otherwise pure and free from organic matter does not materially affect the quality of salted butter. The alkali water flavor of unsalted butter washed in alkali water can be recognized and slightly lowers the quality of the butter.

BACTERIA IN BUTTER AND IN WASH-WATER

Quantitative bacterial analyses were made of the different kinds of water used for washing butter, and also of the butter when fresh, one month, and three months old. Qualitative analyses of bacteria in the water were made to the extent indicated in table 11.

The samples of water and butter reported in table XI are the same as those reported in previous table, No. X. In reality this table should be a part of table X, but is separated for the sake of convenience.

TABLE XI.—Part I.

Showing Number of Bacteria in Alkali Water and Butter

Trial	Kind of Water used	BACTERIA IN WASH-WATER Number per cubic centimeter: Acid	Alkali	Chromogenic	Mold	Neutral Whitish Colonies	Total	Gas Producing	Digestive
1	City	.	.	.....	...	.....	.....	....	....
	Alk. No. 9	.	.	.....	...	.....	.....	....	....
2	C'ndens'd Steam	0	0	268	160	400	828	none	none
	Alk. No. 13	0	0	11000	200	10000	21200	none	none
3	College well	0	0	400	0	800	1200	slight	slight
	Alk. No. 10	0	0	12000	200	31000	43200	m'd'r'te	great
4	College well	0	0	250	0	1440	1690	slight	slight
	Alk. No. 14	.	.	.....	...	.....	.....	....	....
5	College well	0	0	0	0	450	450	none	slight
	Alk. No. 12	0	0	0	0	2200000	2200000	m'd'r'te	v'y gr't
6	College well	0	0	0	0	48000	48000	none	slight
	Alk. No. 13	0	0	0	0	372000	372000	none	slight
7	College well	0	0	0	0	58000	58000	none	slight
	Alk. No. 13	0	0	0	0	370000	370000	none	slight
Av.	well	0	0	153	80	18182	18361	....	....
	Alkali	0	0	4600	200	596600	601280	....	....

TABLE XI. Part II.

Showing Number of Bacteria in Alkali Water and Butter

BACTERIA IN BUTTER

Number per gram of butter

Trial	Kind of water used	When Fresh: Acid	When Fresh: Neutral	When Fresh: Total	When Fresh: Gas Pro-d'c'n	When Fresh: Diges-tion	When 1 month old: Acid	When 1 month old: Mold	When 1 month old: Neutral	When 1 month old: Total	When three months old: Acid	When three months old: Mold	When three months old: Neutral	When three months old: Total
1	City	....	......	....	....	....	......	....	....	....	....	....	....	....
	Alk. No. 9	....	......	....	....	....	......	....	....	....	....	....	....	....
2	C'nd'n'd Steam	3100000	600000	3700000	none	none	100000	1300000	2100000	3500000	0	1200000	950000	2260000
	Alk. No. 13	2900000	700000	3600000	none	none	0	100000	3200000	3300000	1250000	50000	1140000	3530000
3	College well	3010000	1000000	4010000	none	none	600000	400000	4400000	5400000	3000000	30000	0	3030000
	Alk. No. 10	3000000	1030000	4030000	slight	none	1200000	100000	200000	1500000	3000000	20000	90000	3110000
4	College well	4800000	12000	4812000	v. sl.	none	1010000	0	30000	1040000	160000	0	40000	200000
	Alk. No. 14	4700000	162000	4862000	m'd'r'te	none	1920000	0	30000	1950000	28000	0	2000	30000
5	College well	3250000	300000	3550000	slight	none	710000	0	20000	730000	200000	30000	190000	393000
	Alk. No. 12	3100000	290000	3390000	slight	none	700000	0	10000	710000	12000	0	0	12000
6	College well	260000	2000	262000	slight	slight	......	....	....	....	....	....	....	....
	Alk. No. 13	300000	10000	310000	slight	slight	Shipp'd to Chicago		....	....	....	....	....	....
7	College well	7000000	300000	7300000	slight	none	......	....	....	....	....	....	....	....
	Alk. No. 13	11200000	500000	11700000	slight	none	......	....	....	....	....	....	....	....
Avr.	Well	3570000	369000	3939000	....	....	605000	425000	1637500	2667500	840000	315000	295000	1470750
	Alkali	4200000	448667	4648667	....	....	955000	50000	860000	1865000	1072500	17500	308000	1670500

It will be noticed that moulds and chromogenic or color producing bacteria are numerous in the water used in the first experiments. It is possible that the time of year may have some bearing on this. It was during the fall before a hard frost that these experiments were conducted. and the well had not been so thoroughly pumped out previous to this time. Later the ground surface became frozen and covered with snow, which prevented surface seepage water from entering the well. The well was nearly pumped dry each time that the ten cans were filled. This appears to be the only explanation of the change in the bacterial flora of the wash-water during the different seasons.

The number of germs in the college well water also varied considerably. This is as expected. This water is pumped from the well into a large tank, and from there it passes through a system of pipes to the creamery.

The average total number of germs found in the college well water is 21,696 per c. c. and 601.280 per c. c. in the alkali water.

The total average number of germs in the fresh butter washed in the college well water is 3.939,000 per gram. The butter washed in the alkali water contained 4,648.000 per gram of fresh butter.

From the table it will be noticed that the total number of bacteria in these butters decrease with age. When one month old the germ content in the butter washed in alkali water decreased to 2,667,500 per gram, and that washed in the college well water to 1,865,000 per gram of butter. When the butter washed in college well water was three months old the number of germs had decreased to 1,470,750 per gram and the average number of germs in the butter washed in alkali water decreased to 1,670,500 per gram of butter.

One interesting factor of these analyses is that the chromogenic or color producing germs appearing in some of the wash-water are entirely absent from the butter. even when the butter is fresh.

The acid producing germs entirely absent in the wash-water are extremely numerous in the butter especially, while fresh. It appears that the germs of the acid producing species in the cream and churned butter are so numerous that they almost entirely supplant and overcome those germs in the wash water used. This evidently applies only to the particular wash-water used in these experiments, as investigators, notably Jensen, have found that certain species of germs found in water are capable of developing in and decomposing butter.

Another interesting result is the large number of moulds present and developing in the butters in experiments two and three. As indicated in Table No. XI these butters were not salted.

The results of these experiments indicate that the germs in alkali water although more numerous and presenting a different bacterial flòra, are no more deleterious to the quality of the butter than are those present in the ordinary well water and condensed steam used for comparison. In this connection it should be noticed that the creams churned and used in these experiments were properly pasteurized and ripened with a pure culture.

EFFECT OF ALKALI WATER ON CHEESE

The milk from the three cows in Lot II was not used in determining the effect, if any, alkali water might have on the milk for cheese making. These cows gave so small a quantity of milk that too long a time was necessary for obtaining the required amount to make cheese. Secondly they were so near freshening time that it was deemed inadvisable to compare the milk of these cows with that of Lot I. Especially considering the difference that was found to exist in the coagulability of the milk, from this particular lot of cows.

The three cōws in Lot I, not in calf, were fed the alkali water from well No. 13 continuously after the milk and butter data previously reported had been obtained.

Cheese was made from the milk yielded by this lot and compared with the cheese from an equal amount of milk of the remainder of the herd, drinking the normal water from well No. 1.

TABLE XII.

Showing Comparative Scores and Analyes of Cheese Made of Milk from Cows Receiving Alkali, Soft and Normal Water.

Trial	Kind of water drank by cows	Score			Acidity		Analyses when Fresh					Nitrogen as			Analyses when 1 month old					Nitrogen as		
		1 month old	2 months old	3 months old	Fresh	1 month old	Water	Fat	Protein	Ash	Total Nitrogen	Water Soluble Protein	Brine Soluble Protein	Insoluble Protein	Water	Fat	Protein	Ash	Total Nitrogen	Water Soluble Protein	Brine Soluble Protein	Insoluble Protein
1	Well	92	93	90	....	....	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	....	.....	.....	.....	.....
	Alkali	90	90	86	....	....	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	....	.....	.....	.....	.....
2	Well	92	92	90	0.80	0.59	35.43	35.25	24.22	3.08	3.797	0.221	1.431	2.145	33.30	36.48	24.98	3.36	3.915	0.653	2.799	0.463
	Alkali	92	92	90	0.93	0.63	32.26	36.84	25.24	3.36	3.956	0.202	1.054	2.700	30.78	38.04	26.07	3.69	4.086	0.655	2.537	0.894
3	Well	92	91	89	0.48	0.81	34.90	34.77	25.30	3.21	3.966	0.290	2.444	1.232	33.93	35.51	25.59	3.56	4.011	0.794	2.248	0.969
	Alkali	91	92	90	0.42	0.70	32.40	37.25	24.62	3.49	3.859	0.202	0.949	2.70[illegible]	31.76	37.36	25.33	3.55	3.970	0.630	2.146	1.194
4	Well	89	89	87	0.73	0.97	37.20	32.41	24.58	3.11	3.852	0.363	2.852	0.637	36.30	33.40	25.22	3.47	3.962	1.006	2.229	0.727
	Alkali	89	89	88	0.40	0.72	35.36	36.10	23.21	3.19	3.638	0.395	0.810	2.433	34.28	36.72	23.95	3.51	3.755	1.052	1.498	1.205
5	Well	92	91	88	....	....	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	....	.....	.....	.....	.....
	Alkali	93	93	90	....	....	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	....	.....	.....	.....	.....
6	Well	94	93	91	....	....	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	....	.....	.....	.....	.....
	Alkali	93½	92	90	....	....	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	....	.....	.....	.....	.....
	Well	91.8	91.5	89.2	0.67	0.79	35.51	34.14	25.70	3.13	3.872	0.291	2.242	1.338	34.51	35.13	25.26	3.46	3.963	0.818	2.425	0.720
	Alkali	91.4	91.3	89.0	0.58	0.68	33.34	36.73	24.36	3.35	3.818	0.266	0.938	2.614	32.27	37.37	25.12	3.58	3.937	0.779	2.060	1.098

From the various examinations made as to physical and chemical properties and characteristics of milk, it appeared improbable that the quality of the cheese made from the milk of cows receiving alkali water should be effected in any way. Why there should be a difference in the solubility of protein in the fresh cheese the investigators are not prepared to state at this time.

Six comparative trials were made and the cheese scored when one month, two months, and three months old.

Chemical analyses were made of the cheese made in three of these experiments when fresh and when one month old.

As to changes in the curd and characteristics of the cheese throughout the processes of manufacture there were no apparent differences between that made from the milk obtained from the cows receiving alkali water and that made from the milk of cows receiving normal water.

The chemical analyses show one difference in the two kinds of cheese, and that is in the brine soluble protein. In each of the three experiments in which cheese analyses were made the brine soluble protein runs low, the water soluble protein runs a trifle low, and the insoluble protein runs high in the cheese made from the milk of cows receiving alkali water. The extent of difference may be noted from table XII.

This difference in amount of soluble and insoluble protein is much reduced at the end of the first month.

Conclusions

1. Cows receiving alkali water did not produce milk containing a greater per cent nor a greater amount of total minerals than did cows receiving soft water, although each cow receiving alkali water consumed about 0.5 of a pound more of soluble minerals per day than did those fed on soft water.

2. The milk ash from cows receiving the alkali water may vary in its percentage composition without affecting the total per cent of ash. In these experiments the sulphate and potassium were the two chief ash constituents that showed an increase by feeding alkali water. Considering the large amount of sulphates consumed this increase is however small, and so far as the investigators were able to ascetain, this variation in per cent of ash constituents was not sufficiently great to affect in any way the various normal properties of the milk and its products (butter and cheese).

3. The coagulability of milk with rennet was not affected by feeding alkali water to the cows. On the other hand the variation in the coagulability of the milk appears to bear a relation to the per cent of calcium in the milk and individuality of the cow. The milk low in calcium required the most rennet for curdling and produced the softest coagulum; and this milk was produced by cows well advanced in the gestation period.

4. Alkali water, free from decayed organic matter and foreign odors, when fed to cows did not taint the milk, even though the water had a distinctly sharp and slightly saline taste. Neither did the butter made from this milk differ in quality from that made of milk produced by cows receiving normal and soft water.

Some of the alkali water examined was foul and stale and gave evidence of containing decayed organic matter. Such water is dangerous to use for dairy cows, for cleaning dairy utensils, and in connection with the manufacture of dairy products.

5. Butter washed in alkali water and containing a normal percentage of salt, was not found to differ materially in quality from that washed in normal water and condensed steam.

The unsalted butter washed in alkali water was scored about one point lower in quality than was the butter washed in normal wash-water.

Although the alkali wash-water contained a large number of non-acid producing germs, these were almost entirely supplanted by a still larger number of acid producing germs in the butter shortly after its manufacture.

6. The cheese, made from the milk produced by the cows fed alkali water, was normal, both through the various stages of manufacture and during the curing time. By the senses of taste, smell and sight no qualities were found different from those of cheese made of milk from cows receiving normal water.

From the analysis, the brine soluble protein is low, and the insoluble protein is high, in freshly made cheese from the milk produced by the cows receiving alkali water. These differences however are much diminished after the cheese had been cured one month.