CALCIUM AND PHOSPHORUS IN CHEESE MADE UNDER CONTROLLED CONDITIONS

by

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INTRODUCTION

Cheese is generally recommended as a food of high nutritive value, economical as a source of protein, and rich, not only in protein and fat, but also in calcium and phosphorus. The term cheese, however, includes many products of widely different compositions. The literature contains much data on the composition of cheese made in various ways, the mineral content usually being given as total ash with but few figures for the calcium and phosphorus content. The experiments here described were planned to study the calcium and phosphorus content of cheese of several types made under controlled conditions.

REVIEW OF LITERATURE

Theories concerning chemical reactions involved in the clotting of milk may be briefly summarized. In the first place, all proteins are recognized as amphoteric substances. Because of this casein can combine with either acids or bases. In normal milk with a pH on the alkaline side of the isoelectric point of casein, the casein is apparently in combination with calcium as calcium caseinate. According to Bosworth (2) several forms of calcium caseinate may exist.

As lactic acid forms in the milk, the calcium caseinate changes into calcium lactate and uncombined or iso-electric casein, which is insoluble. At the same time the insoluble secondary calcium phosphate of the normal milk changes into soluble calcium acid phosphate and calcium lactate. In the presence of rennin, or other suitable proteolytic enzymes, the casein molecule is split, probably forming molecules of soluble paracasein which unite with calcium to form insoluble calcium paracaseinate. Casein clotted in this way, as calcium paracaseinate on account of the action of rennin, would theoretically contain much more calcium than that clotted as insoluble iso-electric casein due to the change in pH of the solution with the formation of lactic acid. The calcium content of cheese made from clotted casein might therefore be expected to vary, depending on the method of manufacture. The work of Wode (16) with rennet cheese demonstrates these points. Rennet was added to some lots only after acid was present, the acidity due to developed lactic acid or to added hydrochloric acid. The per cent of total calcium of the milk retained in the cheese decreased with increasing acidity at the time the rennet was added with consistent losses of calcium in the whey, a point which has been emphasized by others (15).

Investigations of the phosphorus in the phosphoprotein

casein have been thoroughly reviewed (9, 14). Although casein is known to be a phosphoprotein, the form in which phosphorus is present is still uncertain but it appears highly probable that it may be combined as phosphoric acid. This theory is substantiated by the fact that orthophosphoric acid is readily produced from casein under the action of various mild reagents (10). Linderstrom-Lang is quoted (9) as believing that casein is not an individual substance and has shown that the P/N ratios found in the different fractions are not alike. Hammersten is credited (14) with proving that the phosphorus content of casein is a constant quantity characteristic of the species. The phosphorus content of the casein of cow's milk according to his work is 0.85 per cent.

Figures for the percentage of ash constituents of cheese were made available in the table of ash constituents of foods compiled from various sources by H. C. Sherman, appearing in "Chemistry of Food and Nutrition" (13). These figures, including 0.931 per cent of calcium and 0.683 per cent of phosphorus, have been widely used, as in the various editions of the Laboratory Handbook for Dietetics by Rose, given as Cheese in the revised edition (11) and as Cheese, American, in the third edition (12). Other authors have apparently assumed that these figures hold for various kinds

of cheese, in one instance being applied to American pale, Camembert, Cheddar, Full Cream, Neufchatel, and Roquefort alike (3). Blunt and Summer (1) give interesting data obtained by analysing commercially prepared cheese. These authors found that two rennet cheeses, Swiss and Cheddar, upon analyses, have roughly 14 and 9 times as much calcium as cottage cheese when calculated in terms of per cent and also higher when calculated in proportion to the protein. Blunt and Summer (1) concluded that cottage cheese, unlike hard rennet cheese, must be regarded as a poor source of calcium. However, since rennet was used in the manufacture of cottage cheese, it is a question whether the difference in composition is due to the rennet alone or to some other variable factor in the manufacture of the product. More recently Mallon, Johnson, and Darby (6) analyzed American Cheddar cheese in a study on calcium retention and report figures for the per cent of calcium.

METHOD

The cheeses used in this experiment were made in the laboratories of the Department of Dairy Husbandry, following as much as possible the accepted methods of commercial procedure. Records were kept of details of procedure and of results of routine determinations including:

1. Per cent of lactic acid present, calculated from titration with N/10 NaOH, phenolphthalein used as an indicator.
2. Per cent of fat by Mojonnier milk test.
3. Per cent of total solids by the Mojonnier method.

A sample from each lot of cheese was retained to be further analyzed in the laboratories of Food Economics and Nutrition. Standard methods were used--the calcium determinations being made according to a modification of McCradden's method (7), the phosphorus by the method approved by the Association of Official Agricultural Chemists (8), and the nitrogen by the Kjeldahl-Gunning method (8).

Data available were used to prepare tables showing variations in methods of manufacture and amounts of calcium and phosphorus in the different products with specific comparisons to the fat, protein and calorie content.

Neufchatel cheese, made as indicated in Table I, was allowed to set, until coagulation had taken place with a distinct whey layer formed over the curd. The respective lots of cheese were then poured onto draining cloths, and allowed to drain as completely as possible, and then weighted down and pressed over night, after which samples were secured. The small variation in amount of starter added seemed to have no influence upon the composition of the

TABLE I

MANUFACTURE OF CHEESES USED

Kind	No. of lots	Material used	Per cent of butter fat in material	Pounds of material in one lot	Pasteurization Temp.	Pasteurization Time (Min)
Neufchatel	7	Whole milk	4	8	160° F.	10
Cream	1	Sweet cream	16	19.5	160° F.	10
	6			30.0		
Cottage, rennet	7	Skim milk	.05-.10	8	145° F.	30
Cottage, acid	7	Skim milk	.05-.10	8	145° F.	30
Cottage, acid on commercial basis	6	Skim milk	.05-.10	510-645	145° F.	30
Cottage, acid	1				175° F.	5
	1				160° F.	15
	1	Skim			145° F.	30
	1	milk	.05-.10	8	145° F.	30
Cheddar	9	Whole milk	3.3	800	145° F.	30

TABLE I (Continued)

Per cent of starter	Setting Temp.	Rennet* per 1000 milk (cc.)	Acidity per cent	Yield per cent	Kind
0.2-0.4	74° F.	8-12	0.56	20.83	Neufchatel
0.4-0.5	70-74°F.	0.0	0.75	36.88	Cream
0.7-2.1	72° F.	1.25	0.65	23.5	Cottage, rennet
0.7-2.1	72° F.	0.0	0.62	20.8	Cottage, acid
1.5	88° F.	0.0	0.57	15.78	Cottage, acid on commercial basis
1.5	88° F.	0.0	0.68 0.72 0.70 0.70	25.0 20.3 18.7 20.3	Cottage, acid
2.5	86° F.	72	-	Approx. 10.0	Cheddar

*Liquid rennet obtained from Marshall Dairy Laboratories, Madison, Wisconsin.

curd. The lots made were divided into two groups, N I, that which had not been so well drained and N II, that which had been drained more completely, resulting in a small yield and consequently a greater per cent of total solids and of fat. This cheese, particularly N I, as made in the laboratory has a higher moisture content than commercial Neufchatel, which is due, in part at least, to less pressing in the draining process.

In making cream cheese, each lot of cream was inoculated with a commercial starter, and was held at the setting temperature until the cheese showed an acidity of about 0.7 per cent expressed as lactic acid. As soon as the desired acidity was developed, water equal to 20 per cent of the volume was added to each lot of cheese, and the temperature of the cheese gradually raised to 130° F. in a water bath. Two per cent of salt by weight was added to each lot of cheese during the heating period. The cheese was stirred at frequent intervals until the desired temperature was attained, poured into draining bags and allowed to drain for several hours. Light pressure was applied to the cheese over night, and the following morning it was weighed and sampled.

In manufacturing cottage cheese of the rennet type, the cans of coagulated milk were placed in water, the curd broken, and the temperature of the curd raised slowly to the cooking

temperature (120°-132° F.). Each lot of cheese was held at this temperature until the curd was properly formed. The whey was removed, the curd washed with cold water, spread out on the bottom of the commercial cheese vat and allowed to drain. At the completion of the draining process the cheese was weighed and samples secured for analyses reported in this paper. Two of the samples of the rennet type of cottage cheese (RC I) were not drained so completely as the others which were more similar to commercially prepared cheese.

For the acid type of cottage cheese (C I) the curd was broken and cooked (100°-110° F.) until sufficiently firm. After washing and draining the curd was in the form of relatively fine particles instead of larger curd particles which are characteristic of the rennet type of cottage cheese. For the acid type of cottage cheese made on a commercial basis (C II), the water in the jacket of the vat containing coagulated milk was warmed gradually to a temperature of 140° F. The curd was then cut into cubes approximately three-fourths of an inch square, raised gradually to a temperature of 122° F. and held at that temperature until sufficiently firm. The method of manufacture following completion of the cooking period was the same as for the other groups of cottage cheese. This type of cheese resembles the rennet type of cottage cheese very closely. Data is incomplete for

the C II samples which were analyzed at the beginning of the experiment before the nature of the study was fully determined.

Four other samples of acid type cottage cheese, group LC, were manufactured as shown in Table I. For LC 4, 0.1 per cent of a stabilizer known as Kraybin was used. Kraybin is a Kraft-Phoenix commercial preparation said to aid in the retention of moisture and in the development of good texture. Kraybin has the following percentage composition (4):

Moisture	10.30
Protein (N x 6.25)	2.75
Ash	2.58
Gum	28.5
Reducing Sugar	54.1
Starch	0.0
Ca	0.154
P	0.034
Fe	0.0042

The usual commercial procedure was followed in the manufacture of American cheddar cheese.

Two groups of processed cheese were studied:

	No. of samples	Product	Made from
Commercial Products	1	Swiss cheddar processed	
		American cheddar processed	
		Cheese spread	
Laboratory Products	1	American cheddar processed	1 lot of dry, crumbly, aged American cheddar.
	2	American cheddar processed	A mixture, of three lots of American cheddar varying widely with respect to age, flavor, body and texture.

TABLE II

PERCENTAGE OF N, FAT, CA, P IN CHEESE

Cheese	Lot No.	N	Fat	Ca	P
Neufchatel	1	1.371	12.90	0.112	0.171
N I	2	1.407	10.89	0.102	0.149
	3	1.645	11.50	0.105	0.140
	4	1.425	12.03	0.103	0.143
	Av.	1.462	11.83	0.106	0.151
N II	1	1.747	17.28	0.097	0.156
	2	2.253	18.16	0.108	0.194
	3	2.514	19.60	0.102	0.195
	Av.	2.171	18.35	0.102	0.182
Cream	1	0.870	40.50	0.071	0.086
	2	1.126	33.61	0.119	0.092
	3	1.341	32.80	0.076	0.092
	4	0.896	37.58	0.074	0.092
	5	1.020	35.52	0.067	0.089
	6	1.448	36.62	0.055	0.093
	7	0.984	36.79	0.062	0.090
	Av.	1.098	36.13	0.075	0.091
Cottage, rennet	1	1.940	1.02	0.103	0.124
RC I	2	1.641	1.02	0.079	0.144
	Av.	1.791	1.02	0.091	0.134
RC II	1	2.276	0.93	0.099	0.155
	2	1.662	1.02	0.098	0.131
	3	2.401	1.02	0.114	0.186
	4	1.984	1.02	0.104	0.149
	5	2.455	1.10	0.116	0.197
	Av.	2.156	1.02	0.106	0.164
Cottage, acid	1	2.088	1.03	0.130	0.193
C I	2	3.141	1.03	0.117	0.192
	3	2.726	1.03	0.124	0.181
	4	2.666	1.46	0.133	0.187
	5	2.156	1.03	0.131	0.174
	6	2.419	1.03	0.135	0.189
	7	2.498	0.60	0.124	0.185
	Av.	2.671	1.03	0.128	0.186

TABLE II (Continued)

Cheese	Lot No.	N	Fat	Ca.	P
C II	1			0.078	
	2			0.088	
	3			0.124	
	4			0.113	
	5			0.096	
	6			0.087	
	Av.			0.095	
LC	1	2.152	0.82	0.120	0.161
	2	2.428	0.89	0.116	0.172
	3	1.965	0.75	0.110	0.166
	4	2.274	0.82	0.124	0.147
	Av.	2.205	0.82	0.118	0.162
Cheddar	1	6.092	36.5	0.923	0.396
	2	3.904	36.0	0.810	0.368
	3	5.177	33.0	1.049	0.373
	4	5.771	34.5	1.074	0.386
	5	5.750	33.5	0.990	0.347
	6	5.701	44.0	1.091	0.357
	7	5.770	41.0	0.747	0.315
	8	4.319	43.0	0.963	0.355
	9	5.717	39.5	1.035	0.376
	Av.	5.356	37.9	0.965	0.365
Processed	1	5.477	29.30	0.914	0.354
	2	5.138	29.50	0.962	0.345
	3	4.561	29.08	0.709	0.368
	Av.	5.057	29.29	0.862	0.356
Commercial					
Cream	1	1.379	39.08	0.070	0.096
Processed	1	3.688	30.36	0.695	0.358
	2	3.838	24.30	0.865	0.341
Cheese spread	1	3.565	23.61	0.649	0.497

TABLE III

DATA FROM ANALYSES OF CHEESE MADE IN THE LABORATORY

	No. of samples	Cheese gms.	Calories	Protein (N x 6.38) gms.	Fat gms.	Calcium gms.	Phosphorus gms.
Neufchatel (N I)	4	1.00	1.44	0.0933	0.1183	0.00106	0.00151
		69.4	100.0	6.48	8.21	0.074	0.105
		10.7	15.4	1.0	1.266	0.011	0.016
Neufchatel (N II)	3	1.00	2.21	0.1385	0.1855	0.00102	0.00182
		45.2	100.0	6.26	8.29	0.046	0.082
		7.2	15.9	1.0	1.321	0.007	0.013
Cream	7	1.00	3.53	0.0701	0.3613	0.00075	0.00091
		28.3	100.0	1.98	10.22	0.021	0.026
		14.3	50.5	1.0	5.17	0.011	0.013
Cottage, rennet (RC I)	2	1.00	0.71	0.1143	0.0102	0.00091	0.00134
		140.8	100.0	16.09	1.44	0.128	0.189
		8.7	6.2	1.0	0.09	0.008	0.012
Cottage, rennet (RC II)	5	1.00	0.80	0.1375	0.0102	0.00106	0.00164
		125.0	100.0	17.19	1.28	0.133	0.205
		7.3	5.8	1.0	0.07	0.008	0.012
Cottage, acid (C I)	7	1.00	0.93	0.1704	0.0103	0.00128	0.00186
		107.5	100.0	18.32	1.11	0.138	0.200
		5.9	5.5	1.0	0.06	0.008	0.011

TABLE III (Continued)

	6	1.00				0.00111		
acid (C II)								
Cottage, acid (LC 1)	1	1.00	0.78	0.1373	0.0082	0.00120	0.00161	
		128.2	100.0	17.60	1.05	0.154	0.206	
		7.3	5.7	1.0	0.06	0.009	0.012	
Cottage, acid (LC 2)	1	1.00	0.86	0.1549	0.0089	0.00116	0.00172	
		116.3	100.0	18.01	1.04	0.135	0.200	
		6.5	5.6	1.0	0.06	0.008	0.011	
Cottage, acid (LC 3)	1	1.00	0.73	0.1254	0.0075	0.00110	0.00166	
		137.0	100.0	17.18	1.03	0.151	0.227	
		8.0	5.8	1.0	0.06	0.009	0.013	
Cottage, acid (LC 4)	1	1.00	0.81	0.1451	0.0092	0.00124	0.00147	
		123.5	100.0	17.92	1.01	0.153	0.182	
		6.9	5.6	1.0	0.06	0.009	0.010	
American Cheddar	9	1.00	4.81	0.3417	0.3790	0.00965	0.00365	
		20.8	100.0	7.11	7.88	0.201	0.076	
		2.9	13.9	1.0	1.10	0.028	0.011	
Process	3	1.00	4.15	0.3778	0.2921	0.00882	0.00356	
		24.1	100.0	9.10	7.06	0.208	0.086	
		2.6	10.8	1.0	0.08	0.022	0.009	

TABLE IV

DATA FROM ANALYSES OF COMMERCIAL CHEESE

	No. of samples	Cheese gms.	Calories	Protein (N x 6.38) gm.	Fat gms.	Calcium gms.	Phosphorus gms.
Cream	1	1.00	3.86	0.0880	0.3903	0.00070	0.00096
		25.9	100.0	2.28	10.11	0.018	0.025
		11.4	44.0	1.0	4.45	0.008	0.011
American Process	1	1.00	3.67	0.2353	0.3038	0.00695	0.00358
		27.2	100.0	6.40	8.26	0.189	0.097
		14.2	15.4	1.0	1.28	0.029	0.015
Swiss Process	1	1.00	3.17	0.2441	0.2430	0.00865	0.00341
		31.5	100.0	7.69	7.65	0.272	0.107
		4.1	13.0	1.0	1.00	0.035	0.014
Cheese Spread	1	1.00	3.03	0.2274	0.2361	0.00649	0.00497
		33.0	100.0	7.50	7.79	0.214	0.164
		4.4	13.3	1.0	1.04	0.029	0.022

To make processed cheese, the cheddar cheese was cut into small pieces and passed through a food chopper. The ground cheese was then placed in a copper jacketed kettle to which a small quantity of water and emulsifying agent had been previously added. The quantity of water varied from 18.9 to 27.9 per cent of the weight of the cheese. The emulsifying agent, sodium citrate, was varied from 1.8 to 3.0 per cent of the weight of the cheese. The cheese was slowly heated with constant and vigorous stirring to the desired temperature (155° F.-162° F.). The product was cooled, sampled and packaged.

RESULTS

The data obtained from quantitative determinations are shown in Table II. This data was used to compile Tables III and IV which have been arranged so that comparisons can be made of constituents per gram of cheese, per 100 calories of cheese, and per gram of protein in the cheese. In calculating calories, the usual physiological fuel values (12) were used:

Protein, 4 calories per gram.

Fat, 9 calories per gram.

Carbohydrate, 4 calories per gram.

Allowance for 4 per cent of carbohydrate was made in cottage cheese.

Whether compared as calories per gram of cheese or as grams of cheese necessary to give 100 calories, various cheeses show a wide range due largely to the variations in the moisture and the fat contents. For instance, high calorie values are found for American cheddar (4.81 calories per gm.) a concentrated cheese containing 38.21 per cent of fat, and also for cream cheese (3.53 calories per gm.) a moist product containing however, 36.13 per cent of fat. On the other hand, some of the cottage cheeses high in moisture and low in fat have less than 1 calorie per gram. The percentage of fat in the cheese depends upon the material used in manufacture, as:

Cottage cheese (C I) from skim milk, 1.03% fat

Neufchatel cheese (N II) from whole milk, 18.35% fat

Cream cheese, from 16% cream, 36.13% fat

or upon the moisture content as illustrated by two whole milk cheeses:

Neufchatel (N II), moist cheese, 18.35% fat

Cheddar, concentrated cheese, 38.21% fat.

Cheeses exhibit a wide range of protein content. For the samples analyzed, the figures were approximately:

Cheddar and processed cheese

made in laboratory .....1/3 protein by weight

Commercial processed cheese .....1/4 " " "

Cottage and Neufchatel cheeses .1/6-1/10" " "

Cream cheese .....1/14 " " "

The calcium and phosphorus in the cheese should be compared on several different bases. In the first place, the percentage or the amount per gram is an important figure, the main differences being presented as follows:

Soft cheeses, about 0.1% Ca; approximately 0.15% P.

Cheddar cheese, about 1.0% Ca; approximately 0.36% P.

The cream cheese has the lowest figure for both calcium and phosphorus of the soft cheeses, which may be explained partly by the high percentage of fat in the product. A comparison on the basis of 100-calorie portions shows:

Cottage cheese, made from skim-milk, less than 0.15 gms. Ca, about 0.20 gms. P.

Cheddar cheese, made from whole milk, 0.20 gms. Ca, about 0.07% gms. P.

Neufchatel cheese (N), made from whole milk, 0.074 gms. Ca, 0.105 gms. P.

Cream cheese, made from 16% cream, 0.021 gms. Ca, 0.026 gms. P.

To compare the composition of the cheese, avoiding

variations due to the fat and moisture content of the products, results have been tabulated as calcium and phosphorus per one gram of protein and may be summarized as follows:

Soft cheeses, less than .009 gm. Ca, more than .012 gm. P.

Cheddar cheese, .028 gm. Ca, .010 gm. P.

The results obtained from this experiment indicate that phosphorus is proportional to the protein in cheese regardless of the method of manufacture but that the calcium is more or less dependent upon the method of manufacture involving different chemical reactions. In cheddar cheese approximately 85 per cent of the phosphorus is accounted for by the protein while in the cottage cheese 75 per cent is calculated as contained in the protein.

Cheddar cheese which is made with rennet showed a high calcium content even when calculated on the basis of the protein present. This is in accord with the theories of the clotting of milk as the rennet, which in the manufacture of cheddar cheese is added before the milk becomes acid, was responsible for the formation of paracasein producing an insoluble calcium paracaseinate, resulting in a calcium rich curd. However when rennet is added in the manufacture of cottage cheese, the addition is made in small quantities

after the milk has reached a certain acidity, a procedure necessary to give a tender curd and a palatable product. The results show little difference in the calcium content of rennet and acid types of cottage cheese. Here again the theory is confirmed by data obtained. As lactic acid forms, there are produced calcium lactate, which is readily lost in the whey, and a calcium low curd. Figures for the calcium per gram of protein may be compared:

Acid type cottage cheese, .008-.009 gms. Ca.

Rennet " " " , .008 " "

Cheddar cheese , .028 " "

The per cents of calcium and phosphorus of the milk which were retained in the various types of cheese, as calculated from the yield per 100 pounds of milk, are of interest:

	Calcium	Phosphorus
M I	22.3	40.9
M II	12.8	29.4
Cream	29.2	38.6
RC I	23.5	44.0
RC II	17.6	34.7
C I	21.8	40.3
C II	18.0	-
LC 1	24.6	41.9
LC 2	19.3	36.4
LC 3	16.9	32.3
LC 4	18.3	31.1
American cheddar	80.4	38.1

It will be seen in the LC group of cottage cheese in which there was only the variation of the individual pasteurization temperatures, that the per cent of calcium and

TABLE V

SHARES

1 share in calories = 100 Cal.

1 share in protein = 2.5 gms.

1 share in calcium = .023 gms.

1 share in phosphorus = .044 gms.

Cheese	Grams	Calories	Protein	Calcium	Phosphorus
Laboratory:					
N I	69.5	1	2.59	3.22	2.39
N II	45.25	1	2.51	2.00	1.86
Cream	28.3	1	0.79	0.91	0.59
RC I	140.8	1	6.44	5.57	4.30
RC II	125.0	1	6.88	5.78	4.66
C I	107.5	1	7.33	6.00	4.55
LC 1	128.2	1	7.04	6.70	4.68
LC 2	116.3	1	7.20	5.87	4.55
LC 3	137.0	1	6.87	6.56	5.16
LC 4	123.5	1	7.17	5.91	4.14
Cheddar	20.8	1	2.85	8.73	1.68
Process	24.1	1	3.64	9.04	1.95
Commercial:					
Swiss Process	31.5	1	3.08	11.83	2.43
American Process	27.2	1	2.56	8.22	2.20
Cheese Spread	33.0	1	3.00	9.30	3.73
Cream	25.9	1	0.91	0.78	0.57

phosphorus retention decreased according to the decrease of pasteurization temperature which was accompanied by an increase of time. However, it is felt that definite conclusions on this point are not justifiable because of the few samples analyzed.

In the field of nutrition shares are often used as a simple method of presentation of the nutritive values of foods. The share is represented as 1/30 of the average man's daily requirement (12) and specific figures are given for shares in calories, protein, calcium, phosphorus and iron. These figures are calculated from the quantities which the average man is said to need: 3000 calories, 75 grams of protein, 0.68 grams of calcium, 1.32 grams of phosphorus, and 0.015 grams of iron daily. Table V gives the values in shares of the various types of cheese analyzed, showing the differences in the protein, calcium and phosphorus supplied by 100 calorie portions.

SUMMARY

Fifty-four samples of cheese, fifty being laboratory products made under known conditions, were analyzed for calcium, phosphorus and nitrogen. The types of cheese included rennet and acid types of cottage cheese, cream, Neufchatel, cheddar and processed cheese. From the compiled data the following points are outstanding:

1. Calorie values vary from 4.81 calories per gram for cheddar cheese and 3.53 calories per gram for cream cheese to less than 1 calorie per gram for various types of cottage cheese.
2. Cheddar and processed cheese made under known conditions contain by weight about 1/3 protein, commercial processed cheese 1/4 protein, cottage and Neufchatel 1/6-1/10 protein, and cream cheese about 1/14 protein.
3. The difference in the per cent of calcium in rennet and acid types of cottage cheese is not significant but cheddar cheese contains approximately 10 times as much calcium as the soft cheeses. The amount of calcium seems to vary according to the method of manufacture for when rennet is added before the milk has become acid much more calcium is retained in the curd. About 20 per cent of the calcium of the milk is retained in the soft cheeses while 80 per cent is retained in cheddar cheese.
4. The amount of phosphorus seems to vary according to the amount of protein in the cheese. About 37 per cent of the phosphorus of the milk is retained in the soft cheeses as compared with 38 per cent in cheddar cheese.

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REFERENCES CITED

1. Blunt, Katharine and Sumner, Emma.
   1928 The Calcium of Cheese.
   J. of Home Econ. 20, 587-90.

2. Bosworth, A. W.
   1921 Studies of Infant Feeding XII. The Casein of Cow's Milk and Human Milk in Their Relation to Infant Feeding. The Action of Rennin on Casein.
   Am. J. Dis. Child. 22, 193-201.

3. Bradley, Alice V.
   1931 Tables of Food Values. 128 pages.
   The Manual Arts Press, Peoria, Ill.

4. Kansas State Experiment Station.
   1932 Unpublished Data.

5. Mahin, E. G.
   1924 Quantitative Analysis. Third Edition.
   595 pages.
   McGraw-Hill Book Co. Inc., N. Y.

6. Mallon, M. G., Johnson, L. M., and Darby, C. R.
   1932 A Study of the Calcium Retention on a Diet Containing American Cheddar Cheese.
   J. of Nutr. 5, 121-126.

7. McCrudden, F. H.
   1910 The Quantitative Separation of Calcium and Magnesium in the Presence of Phosphates and Small Amounts of Iron Devised Especially for the Analysis of Foods, Urine, and Feces.
   J. Biol. Chem. 7, 83.

8. Official and Tentative Methods of Analyses of the
   1924 Association of Official Agricultural Chemists. Second Edition. 535 pages.

9. Palmer, L. S.
   1930 Some Recent Advances in the Chemistry of Milk.
   J. Ind. and Eng. Chem. 22, 39-42.

10. Rimington, Claude.
1927 The Phosphorus of Caseinogen.
Biochem. J. 21, 1179-86.

11. Rose, M. S.
1921 Laboratory Handbook for Dietetics.
Revised Edition. 156 pages.
The MacMillan Co., N. Y.

12. Rose, M. S.
1929 Laboratory Handbook for Dietetics.
Third Edition. 269 pages.
The MacMillan Co., N. Y.

13. Sherman, H. C.
1926 Chemistry of Food and Nutrition.
Third Edition. 636 pages.
The MacMillan Co., N. Y.

14. Sutermeister, Edwin.
1927 Casein and Its Industrial Applications.
American Chemical Society Monograph
Series, 296 pages.
Chem. Catalog Co., Inc., N. Y.

15. Van Slyke, L. L.
1928 Chemistry of Sour Milk.
Tech. Bull. No. 140., N. Y. Exp. Sta.

16. Wode, Gunnar.
1930 Effect of Method of Preparation on the
Calcium Content and Consistency of Cheese.
Kgl. Landtbruks-Akad. Handl. Tod. 69,
1032-43.