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Contents

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THE RELATIONSHIP OF ERRORS IN THE BABCOCK TEST TO LOSSES IN CREAM PLANTS

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An economic factor of great importance in the operation of cream plants is the loss of butterfat. The significance of certain errors in the Babcock test in contributing to such losses has apparently not been recognized.

Numerous comparisons of fat tests by the Babcock and Roese-Gottlieb or Mojonnier method have been published for both milk and cream. Tables 1 and 2 show the averages of all of these comparisons that have come to the attention of the authors, including some previously unpublished data obtained in these laboratories.

TABLE 1

Comparisons between Babcock and Mojonnier tests on fluid milk

Reference	Number of samples	Babcock test	Mojonnier test	Difference	Difference expressed as per cent of Babcock test
(1)	1	4.409	4.365	−0.044	
(2)	190	4.497	4.438	−0.059	
(3)	60	4.000	3.840	−0.160	
(4)	32	4.770	4.670	−0.100	
(5)	30	3.601	3.611	+0.010	
(6)	513	3.757	3.675	−0.082	
(7)	16	4.118	4.061	−0.057	
(8)	3	3.533	3.444	−0.089	
(9)	14	3.783	3.809	+0.026	
(10)	36	4.204	4.088	−0.116	
(11)	14	4.230	4.210	−0.020	
(12)	50	3.881	3.822	−0.059	
(13)	21	4.275	4.242	−0.033	
(14)	900	4.548	4.472	−0.076	
Average from literature	1880	4.257	4.181	−0.076	
Hileman *et al.* ...	149	3.484	3.411	−0.073	
Grand average...	2029	4.200	4.124	−0.076	1.80

For details of the technique of performing the Babcock and Mojonnier tests in the work cited from the literature, the original articles should be

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consulted. It might be well to note that the comparisons made by Dahlberg, Holm and Troy (5) were complicated by the facts that the samples were chemically preserved and were transported, in part at least, by mail. So far as is known, all other samples were not chemically preserved. Wilster and Robichaux (14) have reported some comparisons on preserved samples

TABLE 2

Comparisons between Babcock and Mojonnier tests on cream

Reference	Number of samples	Babcock test	Mojonnier test	Difference	Difference expressed as per cent of Babcock test
(4)	34	36.931	36.800	−0.131	
(5)	33	32.360	32.290	−0.070	
(15)	10	26.475	26.193	−0.282	
(7)	4	32.047	32.087	+0.040	
(9)	14	18.621	18.182	−0.439	
(16)	23	39.774	39.067	−0.707	
(17)	24	33.968	33.966	−0.002	
Average from literature	142	33.149	32.925	−0.224	
Hileman *et al.* ...	186	38.160	37.668	−0.492	
Grand average...	328	35.991	35.615	−0.376	1.04

also, but only their 900 comparisons on fresh samples have been included in table 1.

For the comparisons made in these laboratories, here published for the first time, all Babcock testing of milk was done in exact accordance with the procedure specified by the New York State Department of Agriculture and Markets (18). All glassware was rechecked at the Experiment Station at Geneva and bore the "SB" designation. Sulphuric acid of density 1.825 to 1.828 at 60° F. was used. All tests were in duplicate, and no results were used unless each of the two duplicates had a perfect fat column and the two agreed within 0.1 per cent. All tests were read after tempering at least 5 minutes in a water bath at 135-140° F. Water added to the bottles to bring the fat column up into the neck was at 165° F. ± 3°, which is now recognized as correct for heated centrifuges in New York State, although it was not so recognized during all of the several years during which the data were being accumulated (19).

Babcock tests on cream were made in these laboratories also in exact accordance with the procedure outlined by the New York State Department of Agriculture and Markets, with two exceptions. Water used to bring the fat columns up into the necks of the bottles was at a temperature of about 165° F. (See the last sentence of the preceding paragraph.) The bottles used were especially made, nine inches long instead of six inches long, and with the necks graduated to read up to 60 per cent fat. Because of the longer graduated necks, tests could easily be read to 0.25 per cent. These

bottles were all rechecked by the New York State Agricultural Experiment Station at Geneva, New York, and any showing an error greater than 0.25 per cent were rejected. This is only half the error that is allowed for state-branding of ordinary Babcock cream test bottles. Numerous comparisons with state-branded 50 per cent six inch cream test bottles showed that the longer bottles gave identical results, within the limits of accuracy of the Babcock test. All tests were in duplicate, and only perfect fat columns were read. Only results where duplicates agreed within 0.50 per cent were used. All tests were read after tempering for 5 minutes in a water bath at 135–140° F. "Red reader" was used to flatten the upper meniscus.

Mojonnier tests were run in exact accordance with the procedure outlined in "The Technical Control of Dairy Products" by Mojonnier and Troy (11), except for certain special precautions. Ethers were all redistilled. Milk samples were either weighed directly into the fat-extraction flasks or pipetted from high-grade carefully re-calibrated 10 ml. chemical pipettes, with fine tips to insure uniform delivery. The latter method, using a cold sample to avoid possibility of churning, has proved to be the most satisfactory for measuring fluid milk samples for Mojonnier tests. Warming samples is apt to cause enough churning to be significant in Mojonnier tests. Weighing samples in pipettes often allows formation of gravity cream in the pipette which may stick to the walls of the pipette and cause appreciable errors. It is obvious that the calibration of the pipette should be with milk at the same temperature as that used when the samples for analysis are transferred to the flasks.

Cream samples for Mojonnier tests were weighed in pipettes, the samples being at room temperature. A third extraction, using 15 ml. of each ether, was used with cream. All Mojonnier tests were in duplicate, and only those tests with duplicates agreeing within 0.03 per cent for milk, and within 0.25 per cent for cream, were used. Most of the duplicates were much closer than these extreme limits.

The "difference expressed as per cent of the Babcock test" is 1.80 for milk. This means that, for every 100 pounds of fat in milk purchased, the purchaser pays for 101.80 pounds. If this milk is made into cream and sold, the manufacturer gets paid for 101.04 pounds of fat. The difference, or 0.76 pounds, represents a loss of 0.76 per cent which cannot be avoided so long as present methods of Babcock testing are used.

It seemed desirable to determine if the richness of the milk skimmed and of the cream produced has any bearing on the magnitude of this loss. In order to do this, it was decided to analyze the data of Fahle, Lucas and Baten (6) on milk, and of the authors on cream. These particular sets of data were chosen in order to have a large number of comparisons covering a wide range of fat content. It would be better to have the data for both milk and cream from a single laboratory, but there appears to be no work available

TABLE 3

Variation of the difference between Babcock and Mojonnier tests on milk with variation in fat test. From work of Fahle, Lucas and Baten (6)

Range of Babcock tests	Number of samples	Average Babcock test	Average Mojonnier test	Difference	Standard deviation of the difference	Probable error of determining the average difference	Difference expressed as per cent of Babcock test
3.00–3.49	143	3.341	3.282	−0.059	0.079	±0.0044	1.76
3.50–3.99	254	3.705	3.624	−0.081	0.091	±0.0038	2.18
4.00–4.49	79	4.218	4.120	−0.098	0.092	±0.0070	2.32
4.50–4.99	32	4.666	4.534	−0.132	0.111	±0.0132	2.82
5.00 and up	5	5.126	4.933	−0.193	0.047	±0.0142	3.76
Average	513	3.757	3.675	−0.082	0.092	±0.0021	2.18

TABLE 4

Variation of the difference between Babcock and Mojonnier tests on cream with variation in fat content

Cream standardized to	Number of samples	Average Babcock test	Average Mojonnier test	Difference	Standard deviation of the difference	Probable error of determining the average difference	Difference expressed as per cent of Babcock test
20	45	20.317	20.159	−0.158	0.298	±0.030	0.77
40	88	40.171	39.644	−0.527	0.280	±0.020	1.31
50	53	49.972	49.255	−0.717	0.324	±0.030	1.43
Average	186	38.160	37.668	−0.492	.....	.....	1.28

which meets the above requirements. The authors have data, shown in tables 1 and 2, for both milk and cream, but the range of fat content for the milk samples is very narrow.

Tables 3 and 4 show the results of analyzing these data, as discussed above.

From an examination of tables 3 and 4, it is obvious that the difference between the Babcock and Mojonnier tests increases with the fat content for both milk and cream, and that the difference expressed as per cent of the Babcock test is smaller for cream than for milk. This means that the skimming loss due to the error in the Babcock test will increase with increasing fat content of the milk skimmed and will decrease with increasing fat content of the cream produced. Table 5 shows this more in detail.

TABLE 5

Variation in per cent skimming loss due to errors in the Babcock test with variation in fat content of milk skimmed and cream produced

Fat test of cream	Fat test of milk					
	3.34	3.70	4.21	4.66	5.12	Average 3.75
20.317	0.99	1.41	1.55	2.05	2.99	
40.171	0.45	0.87	1.01	1.51	2.45	
49.972	0.33	0.75	0.89	1.39	2.33	
Average 38.160						0.90

Another source of loss in the manufacture of cream, which is often overlooked because of an error in the Babcock test, is fat in the skim milk. Table 6 shows a comparison of Babcock and Mojonnier tests on skim milk. In the case of milk and cream, the Mojonnier test is slightly lower than the Babcock. In the case of skim milk, however, the Mojonnier test is about seven times as high as the Babcock. For efficiently operated separators, the Babcock method gives a test of about 0.01 per cent on the skim milk. This is so low that much butterfat accounting ignores it entirely. However,

TABLE 6

Comparisons between Babcock and Mojonnier tests on skim milk

Reference	Number of samples	Babcock test	Mojonnier test	Difference	Difference expressed as per cent of Babcock test
(4)	15	0.0140	0.0870	+ 0.0730	
Hileman *et al.*	60	0.0102	0.0691	+ 0.0589	
Average	75	0.0109	0.0726	+ 0.0617	566.05

the true fat content by the Mojonnier test is about 0.07 per cent. If milk testing 3.5 per cent fat is skimmed, this means that 2 per cent of the fat will not be recovered in the cream. Failure to recognize its presence in the skim milk means that there will be an unexplained loss of 2 per cent of the fat purchased.

An illustration of how these factors affect losses in an actual cream plant is given by an experiment. During a fifteen-day period, the milk and cream in a certain cream plant were carefully weighed, and both were tested by both Babcock and Mojonnier methods. The dry skim milk produced was also tested by the Mojonnier method. Table 7 gives a comparison of losses by the two methods of testing.

TABLE 7

Losses in a cream plant on the basis of Babcock and Mojonnier tests, for a 15-day period

	Mojonnier test	Babcock test
Pounds milk skimmed	826,425	826,425
Average test of milk	3.38395	3.46042
Pounds fat in milk	27,965	28,597
Pounds cream made	68,725	68,725
Average test of cream	39.71335	40.21971
Pounds fat in cream	27,293	27,641
Per cent of the fat in the milk recovered in the cream	97.60	96.65
Pounds dry skim milk made	67,050	Neglected
Average test of dry skim milk	0.74407	
Pounds fat in dry skim milk	498	
Per cent of the fat in the milk recovered in dry skim milk	1.78	
Pounds fat lost	174	956
Per cent fat lost	0.62	3.35

The Babcock test, with the fat in the skim milk neglected, shows 782.9 pounds more loss than does the Mojonnier. Of this amount, 284.0 pounds are due to the error in the Babcock test for milk and cream, equivalent to 0.99 per cent of the fat in the milk. The fat in the skim milk, 498.9 pounds, is equivalent to 1.74 per cent of the fat in the whole milk. The fat actually lost was only 173.9 pounds, equivalent to 0.62 per cent of the fat in the whole milk.

SUMMARY

The Babcock test gives a result that is too high in the case of both milk and cream. Because the error is proportionately greater in milk than in cream, a loss results. This loss increases with increasing fat content of the milk skimmed, and decreases with increasing fat content of the cream produced. It may vary from about 0.35 per cent where cream testing 50 per

cent fat is made from milk testing 3.35 per cent fat, up to about 3 per cent where cream testing 20 per cent fat is made from milk testing 5 per cent fat.

ACKNOWLEDGMENT

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EFFECT OF INHALED SUBSTANCES ON MILK FLAVORS[1]

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Most, if not all, of the commercially-important flavors of milk are exogenous; at least, there is no evidence that the synthesizing mechanism of the udder produces any of these flavors. This concept requires that the flavoring substance is present in the blood and the "membranes" of the mammary gland are permeable to it. There are three possible avenues through which flavoring substances may gain entrance to the blood: (a) through the walls of the alimentary tract from ingested material; (b) through the lungs from inhaled substances; and (c) through the skin from contacted substances. The further possibility also exists that flavors or odors from ingested material may gain entrance to the blood by passing progressively from the point of rumination to the lungs and then into the blood.

This report will deal with some preliminary experiments in a study of the effect of certain inhaled substances upon the flavor of milk. While there is a considerable amount of literature (2) dealing with the effect of different ingested substances upon milk flavors, there is a scarcity of information upon the effect of inhaled substances. Aside from the general knowledge that milk from animals recently anesthetized with ether or chloroform contains these anesthetics and the report by Babcock (1) that inhaled odors of wild garlic tops could be detected in the milk, the authors are unaware of any reports in the literature dealing with the specific effect of inhaled substances upon milk flavors. It is rather common knowledge, however, that inhaled gases such as methane, nitrous oxide, hydrogen cyanide, chlorine, bromine, etc., and vapors from many compounds pass through the lungs into the blood. Because of these facts and the fact that the mammary gland behaves as a permeable membrane to many substances in the blood, it was thought advisable to begin an investigation of the effect of certain inhaled substances upon milk flavors. The substances investigated and reported herein are: turpentine, paradichlorbenzene, benzaldehyde, camphor, vanillin, synthetic orchid, onions, garlic, manure, corn silage, alfalfa silage and scrapings from Roquefort cheese.

PLAN OF THE EXERIMENT

The essential features of the experimental plans upon which comment is needed are: (a) the special stalls, (b) the method of administering the

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[2] Now at Cornell University.

substance to be studied, (c) the milking and sampling, and (d) the judging of the milks.

The Stalls. In order to confine the odors to the head regions of the animal and prevent, insofar as possible, absorption of the odors on the posterior of the body, which might contaminate the milk when drawn, a special stall was constructed. The manger was completely enclosed in a "tent" approximately $4\frac{1}{2} \times 2\frac{1}{2} \times 3\frac{1}{2}$ feet in dimensions. By first putting in wood partitions between the mangers, the "tent" was completed by covering with a heavy duck canvas, cut so as to fit snugly around the animal's neck at the stanchion. A heavy wire screen was fitted over the lower part of the manger in such a manner that at least two inches intervened between the solid materials to be tested and the cow's mouth to insure that none of the substances could be taken by mouth. In order to prevent contamination of the milking barn with odors, the stalls were constructed in a barn separate from where the milking took place.

Method of Administration. In all trials the cows were placed in the tent and inhaled the odors or vapors for two hours immediately before milking. They were then removed to the milking barn. For comparative purposes, turpentine, benzaldehyde, camphor, vanillin and onions were administered orally two hours before milking. The solid substances, paradichlorbenzene, camphor, onions, garlic, manure, corn and alfalfa silage and scrapings from Roquefort cheese, were placed in the manger and covered with the heavy screen immediately before the animal was placed in the stall. The fluid substances, turpentine, benzaldehyde, spirits of camphor, and vanillin solutions (in alcohol) were placed in the manger on cotton for one series of experiments and for another were atomized into the tent. Synthetic orchid was tried only by atomizing. The onions and garlic were crushed before being placed in the manger and the silages were stirred periodically to free a maximum of the volatile substances into the tent.

The mangers were thoroughly washed and aired after each experiment. In the case of paradichlorbenzene, it was not possible to rid the manger completely of this compound and no further experiments were conducted in the stall where it was used.

Taking the Milk Samples. The cows were milked by machine and a quart sample was taken from the completed milking for the judging. The sampling was done in a milk room which was free from contaminating odors. One or more samples from the normal herd cows were taken simultaneously in a similar manner for comparison purposes.

Judging of the Milks. From three to five people,[3] experienced in judging, were used in rating the milks from all trials. The judges had no

[3] The authors are indebted to members of the Dairy Division staff who contributed their time and ability in judging the milks reported herein.

knowledge of the substance investigated, all samples being identified by number, the identity of which was known only to the authors. The mixed herd samples were likewise unknown to the judges. The judges, working independently, not only decided as to whether or not the milk had abnormal flavors but they also commented upon the character of the flavor.

RESULTS AND DISCUSSION

It was noted that the head and that portion of the neck which was inside the "tent" had absorbed the characteristic odor for each substance tested whether or not such could be detected in the milk. The posterior part of the animal's body was free from any absorbed odors insofar as could be ascertained.

A summary of the effects on milk flavor of the substance studied by the various methods of administration are given in table 1. A discussion of the results obtained for each of the substances tested follows:

Turpentine. Whether turpentine was placed on cotton in the bottom of the manger, atomized into the tent or given orally (30 ml. quantity), the milk was pronounced abnormal by all judges in all cases. In the trials where the turpentine was placed in the bottom of the manger, the flavors were less pronounced than where administration was by atomizing or by mouth. In the former, the judges declared that the milks were "aromatic" or "medicinal," while for the trials in which the turpentine was administered by atomizing the judges unhesitatingly pronounced the flavor as that of turpentine or closely allied substances, such as varnish or paint. In the one trial where the turpentine was administered orally, the turpentine flavor of the milk was very distinct as indicated by the fact that all three judges described the flavors as "turpentine."

Paradichlorbenzene. Inhalation of the odors from paradichlorbenzene had such a pronounced effect upon the flavor of the milk that only two trials were necessary to establish the fact that this substance passes through the lungs to find its way ultimately into the milk. The flavor of the milk is unmistakably that of the chemical.

Benzaldehyde. In one trial, involving two cows, benzaldehyde was placed upon cotton in the manger. One judge declared that the milk had a sweetish taste while three judges proclaimed the milk normal. When benzaldehyde was atomized into the "tent" all three of the judges distinguished these milks from the normal or control milks and described them as "aromatic" or, in one instance, as "off flavor." When one ml. of benzaldehyde was administered orally, the judges described the milk as being "sweetish" and "aromatic."

Camphor. Pulverized camphor, placed in the manger, and atomized spirits of camphor produced a decided "medicinal" or "aromatic" flavor, while one judge detected an actual camphor flavor in one case. When

TABLE 1

Summary of the effect of various inhaled or ingested substances upon the flavor of milk

Substance	Method of application	No. of cows	Judges' report		Comments of judges
			Normal No.	Abnormal No.	
Turpentine	Bottom of manger	2	0	4	Aromatic, medicinal
"	Atomized	2	0	5	Turpentine by 3 and aromatic
"	Atomized	2	0	4	Paint, varnish, turpentine
"	29 ml. orally	1	0	3	Turpentine by all 3
Paradichlorbenzene	In manger	2	0	4	Aromatic, moth balls, musty
"	In manger	1	0	3	Aromatic, moth balls, musty
Benzaldehyde	In manger	2	3	1	Sweetish
"	Atomized	2	0	3	Aromatic, off flavor
"	2 ml. orally	2	0	3	Sweetish, vanilla-like
"	4 ml. orally	2	0	3	Sweetish, aromatic
Camphor	In manger	2	0	4	Medicinal, off flavor
Spirits of camphor	Atomized	2	0	4	Medicinal, aromatic
"	Atomized	2	0	3	Medicinal, camphor
"	58 ml. orally	2	0	5	Camphor by 4, medicinal
Vanillin	Atomized	2	0	3	Vanilla by all
"	58 ml. orally	1	0	3	Slightly vanilla
"	29 ml. orally	1	3	0	
Synthetic orchid	Atomized	1	3	0	
Crushed onions	In manger	2	0	4	Sl. objectionable flavor
"	In manger	1	1	3	Feed, sweetish, sl. off
Onions	28.3 gm. orally	1	...	4	Onions, undesirable
"	453.5 gm. orally	1	...	3	Strong onion
Crushed garlic	In manger	2	3	1	Sl. feed flavor
Manure	In manger	2	1	3	Cowy, objectionable
"	In manger	2	1	2	Cowy, unclean
Corn silage	In manger	2	1	3	Feed flavor
Alfalfa silage	In manger	2	1	3	Feed flavor, unclean
Alfalfa strong odor	In manger	2	0	3	Feed flavor by all
Scrapings from Roquefort cheese	In manger	2	3	0	

approximately 58 ml. of spirits of camphor were administered orally to two cows, four judges noted a camphor flavor in the milk and the fifth judge termed the flavor "medicinal."

Vanillin. Atomized vanillin, dissolved in alcohol, caused the milk to have a vanillin flavor which was detected by each of the three judges rating the milk. One ounce (29 ml.) of vanillin per orum caused no flavor change that could be detected by any of the three judges while 58 ml. of orally-administered vanillin caused a slight vanilla flavor which was detected by each of the three judges. As only a small fraction of the vanillin could have been inhaled, this compound appears to be more effective in causing milk flavors when inhaled than when ingested.

Synthetic Orchid. In only one trial with one cow, 58 ml. of synthetic orchid-alcohol solution were atomized into the "tent." None of the three judges could detect any off-flavor in the milk.

Onions. One half bushel of crushed onions in the manger in one trial with two cows produced milk in which all of the four judges detected a slightly objectionable or feed flavor. In a second trial with one cow, one judge pronounced the milk normal and three detected a "feed," "sweetish" and "slightly off" flavor respectively. When onions were administered orally either in 28-gram or 454-gram quantities, all judges criticized the milks as having a strong onion flavor.

Garlic. Garlic, in the bulbous form, was tried in one experiment only, in which case it was placed in the manger in the crushed form. Three judges declared the milk to be normal while one detected a slight feed flavor which he also observed in the normal mixed milk. These results are not in agreement with those obtained by Babcock (1) who was able to detect garlic odor in the milk drawn one minute after a ten-minute inhalation period. The cause of this discrepancy is unknown but it should be noted that Babcock used wild garlic tops while we used crushed garlic bulbs. There may be a sufficient difference in the volatility of the aromatic compounds contained in these two forms of garlic to explain this disagreement.

Our failure to demonstrate typical garlic and also onion odors in milk by inhalation would immediately suggest an inability (or insensitiveness) on the part of judges to recognize these flavors or a low odor concentration in the inhalation tent. The latter seems unlikely in view of the fact that both authors were distinctly aware of strong onion and garlic odors during the inhalation period of these trials.

Manure. Decomposing cow manure was used as the source of odors in two trials involving two cows each. In the first trial, three out of four judges detected "cowy" and "objectionable" flavors in the milk while in the second trial two out of three judges pronounced the milk "cowy" or "unclean." That the flavors were not pronounced is indicated by the fact that one judge in each trial called the milks "normal." However, the other com-

ments indicate that odors of decomposing manure are absorbed through the lungs and find their way into the milk. It is also possible that the effects may be more pronounced after a longer exposure than the routine two hours of these experiments.

Corn Silage. The milk from two cows allowed to inhale the odors from normal corn silage was pronounced to have feed flavors by three judges and to be normal by one judge.

Alfalfa Silage. Two cows exposed to good quality alfalfa silage produced milk which was judged as having a feed or unclean flavor by three out of four judges. When subjected to alfalfa silage with a strong odor, two cows produced milk which was found by all of the three judges to have a decided feed flavor.

Scrapings from Roquefort Cheese. In one trial with two cows, the odoriferous, slimy scrapings from Roquefort cheese produced no noticeable effect upon the milk as all three judges pronounced the milks to be normal.

From the foregoing, it is obvious that some inhaled substances are readily absorbed into the blood and from there pass into the milk. The lung membranes are less permeable to other substances and for this reason, the flavor of the milk is affected to a lesser extent. Then, too, the lung membranes may be highly permeable to some substances, but the udder membranes may be less permeable or even impermeable to these same materials.

Although it is not of consequence in these experiments, the point should be mentioned that exogenous flavors and odors could reasonably pass out of the milk, back into the lungs and eventually be lost to the outside air. That this apparently happens in the cow is amply demonstrated by the fact that feeding silages, etc. four or five hours before milking serves to prevent these feed flavors from occurring in the milk. The mechanism by which the above loss of flavor occurs probably involves flavor or odor concentrations between the milk, blood and lungs. When that of the lung becomes low, as it should with increasing time, the odor equilibrium is shifted toward the lung end. The loss of the odor or flavor to the outside air is similar to removing the product of a chemical reaction and allowing the reaction to go to completion. The net result is a pulling out by the lung of the odor from the milk via the blood until the odor or flavor remaining in the milk becomes unnoticeable.

Among the inhaled pure substances that cause decided flavors in the milk are turpentine, paradichlorbenzene, benzaldehyde, camphor and vanillin. All of these compounds, it should be pointed out, are ether soluble and water insoluble. These properties indicate that the above compounds are probably fat soluble and this is, no doubt, a partial explanation of the readiness with which they pass into the milk via the blood.

Of the compounds just mentioned, all except benzaldehyde impart their characteristic flavor to the milk. A reasonable explanation for the change in flavor of benzaldehyde may lie in a change in the chemical configuration

of this substance as it passes through the animal system. It is not improbable that other ingested or inhaled substances may also be changed in the animal's body so that their flavoring properties are either lost or so altered that they are not recognized.

The failure of the highly volatile and aromatic synthetic orchid compound to be detected in milk after inhalation cannot be explained without further study. This compound may not have been absorbed through the lung, or it may have been absorbed and altered so as to lose its flavoring properties or the mammary gland membranes may be simply impermeable to it.

With regard to the onion and garlic experiments, it is the opinion of the authors that the lung is not permeable to the characteristic flavors of onion and garlic but is permeable to some other flavoring constituent. That the characteristic flavoring compounds, principally allyl sulfide, of onion and garlic are permeable to the mammary gland and are not altered in the system is evidenced by the effects of oral administration of both of these products.

While the results from the inhalation of odors from decomposing manure and silage are not as striking as those from the inhalation of some other compounds, there is unmistakable evidence that they do produce "off flavors" in the milk. This would emphasize the need for keeping the cows in an atmosphere free from undesirable odors before milking.

SUMMARY AND CONCLUSIONS

1. The effects of inhaling the odors from thirteen substances and ingestion of five substances upon the flavor of milk are reported.

2. Inhalation of turpentine, paradichlorbenzene, camphor or vanillin caused flavoring of the milk characteristic of each of these compounds.

3. Inhalation of benzaldehyde, onions and garlic caused a change in the flavor of the milk which was not characteristic of the compound.

4. Inhalation of odors from corn silage, alfalfa silage and decomposing manure, produced "off flavors" in the milk.

5. Inhalation of synthetic orchid or scrapings of Roquefort cheese produced no detectable "off flavor" in milk.

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MILK LIPASE AND MILK FLAVOR

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Milk flavor is a composite property (1, 5). Ultimately all its components must be referable to the individual chemical constituents of milk. In this communication evidence of a relationship of milk lipase to milk flavor is submitted.

Milk lipase brings about the hydrolysis of butterfat glycerides. The liberated fatty acids have the property of lowering the surface tension of milk. Surface tension measurement may, therefore, be used as a convenient method of following milk lipase activity (4). The free fatty acids, however, contribute also to the lowering of the flavor score of milk. They alter the taste and impart a strongly cowy, unclean, or butyric odor to the milk. Since the odor of the volatile fatty acids is fairly readily detected it was decided to utilize this property in a study of the relationship between surface tension and flavor of milk.

Lipolysis can be demonstrated in all raw milk under specified conditions (2). In susceptible milks lipolysis may take place under the usual conditions of handling milk. It follows therefore as a logical possibility that milk lipase may also affect, although to a smaller degree, the flavor of "average" milk under "average" conditions.

An interesting relationship between the decline in milk flavor and the increase in butterfat content of milk held overnight at 5° C. has been reported (5). The question arises whether this effect might not be due to the action of milk lipase.

The problem of the relation of milk lipase to milk flavor is important not only in considering milk as such but also in the study of the flavor of other dairy products, particularly perhaps of raw milk cheddar cheese (3).

EXPERIMENTAL

A total of 144 samples of milk included not more than 4 samples from any individual cow and represented 51 cows from October 14 to December 24, during which time the cows were stabled and stall fed.

Twelve was selected as a convenient number of samples which could be satisfactorily handled during a given day. Accordingly this number of wide-mouth glass-stoppered bottles of about 100 ml. capacity was prepared by washing, treating with chromic-sulfuric mixture and finally steaming. Milk samples were then collected during the evening milking from each pail

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as it was being emptied into the milk can. The bottles were stoppered and the samples stored in a refrigerator at 5° C. overnight.

In the morning the milk samples were brought to 25° C. and after shaking to mix in the cream layer, surface tension was determined by means of the du Noüy tensiometer. Triplicate determinations on 3 portions of each milk were used to obtain an individual result. The platinum-iridium ring was flamed before each determination and a small platinum dish which was also kept clean by flaming served as a container. The results for the 12 samples were then arranged into 3 groups of 4 each with those having the lowest surface tension reading in the first group, those having the highest reading in the third group, and the remainder in the intermediate group. In case any two samples tied for the same group placing, allocation was made by lottery.

In the afternoon the remaining portion of each milk which was not used for surface tension measurement was judged at 25° C. for odor only by 3 judges. The samples were again arranged into 3 groups of 4 as previously, but this time according to odor.

The above procedure was repeated 12 times giving a total of 144 samples. The group placings of each sample according to surface tension and according to odor were then correlated by the usual statistical method, giving a correlation coefficient of 0.23.

DISCUSSION

The volatile fatty acids constitute only one component of milk odor (1,5). Therefore, when milks are judged on the basis of odor other normal components, feed and physiological factors are included. Since these other components are not necessarily related to surface tension, a high correlation coefficient between surface tension and odor cannot be expected.

Again in unselected milk samples a wide variation in properties cannot be expected for all samples. According to normal distribution the majority of milks will be very similar in properties and will be difficult to distinguish from one another either on the basis of surface tension or odor. Similarly the comparison of absolute values of surface tension instead of surface tension lowering is based on the assumption that the surface tension of freshly drawn milks is fairly constant and that any error from this source is small in comparison with the variations obtained among different milks. A certain proportion of the samples may therefore be assigned their group placings on the basis of random distribution rather than on physico-chemical or organoleptic criteria.

Although it is not possible to obviate all the experimental difficulties, they can be minimized. The following expedients were used. Twelve samples were used for each run. Milks were compared organoleptically relative to one another instead of on an absolute basis. They were divided into only 3 groups. The average result of 3 judges' opinions was used.

The interpretation of our experimental result, namely, a correlation coefficient of 0.23 relating the surface tension and milk odor may now be considered. The coefficient is not high, but some of the reasons for this have already been discussed. It might be pointed out by way of comparison that the same value of r was obtained by Weaver (5) in correlating milk flavor with butterfat content of milk. According to statistical tables a value of $r = 0.23$ for 144 samples is definitely significant. It may be concluded, therefore, that milk having a low surface tension after holding at 5° C. will, other things being equal, have a less desirable odor and conversely. Since surface tension is related to lipase activity and odor is a component of flavor, therefore, the flavor of milk is related to its lipase activity.

The magnitude of the correlation coefficient may be interpreted in one of two ways. It may be assumed that a certain proportion of the samples was rancid or slightly rancid. None of the milks, however, was criticized by the judges for this defect. On the other hand, volatile fatty acids may have been present in a large proportion of the milk samples, but due to other variables many of these could not be detected. In other words, if it were possible to select samples in such a way that all factors were constant except for the variables under consideration, a much higher correlation would be expected. This is probably a more accurate interpretation. One is therefore inclined to believe the presence of a small amount of free fatty acids and slight lipolytic activity in normal milk. This is particularly significant because milks used in our investigation were kept under conditions which approximate those in ordinary farm practice.

In our study on the flavor of cheddar cheese the hypothesis was advanced that many of the less definite defects, such as unclean, etc., were probably related to the rancid flavor and were caused by traces of milk lipase (3). Evidence for a parallel condition in milk flavors exists. Thus from the statements by Davis (1) and by Weaver (5) the flavor of freshly drawn milk from a healthy udder may be described as mildly and pleasantly cowy. This appears to develop into a strongly cowy flavor and finally the latter is considered as a forerunner of the rancid flavor. This sequence and relationship of milk flavors find support in our results on the study of the relation of milk lipase to milk flavor in normal milk.

SUMMARY

The relation between lipase activity as indicated by surface tension measurement and flavor as judged by odor was studied. The results on a total of 144 milk samples including not more than 4 samples from one cow and representing 51 individual cows, gave a correlation coefficient of 0.23. The role of milk lipase in average milk under ordinary methods of handling is discussed in relation to the flavor of milk and milk products.

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INCREASED MILK AND MILK FAT PRODUCTION FOLLOWING THE FEEDING OF ARTIFICIALLY FORMED THYROPROTEIN (THYROLACTIN)[1]

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In an earlier communication, the authors (8) have presented evidence demonstrating that artificially formed thyroproteins will replace the function of the thyroid gland in thyroidectomized goats. The successful formation of thyroidally active proteins by relatively simple and inexpensive methods has suggested the practical use of such substances for the stimulation of increased lactation in dairy cattle. Preliminary results on the lactation-stimulating properties of iodinated casein when fed to lactating goats were reported by Turner (10), and at that time the term "thyrolactin" was proposed for such preparations. The present report includes data on the effect of thyrolactin, administered orally over short periods of time, on milk production of goats and milk and milk fat production of lactating cows.

EXPERIMENTAL

Plan of the Experiment. The thyrolactin used was iodinated under the conditions and approximately at the optimal level indicated in the report of Reineke, Williamson and Turner (9). Such preparations were found to have a potency of 1/100 to 1/200 that of synthetic thyroxine as measured by biological assay on guinea pigs and tadpoles.

In the experiments on goats, thyrolactin was given in the daily grain feed in varying amounts over a period of 5 days. Daily measurements of the pulse-rate were taken, as a rough check on the metabolic effect of the treatment. Since it was desired primarily to determine whether or not thyrolactin would affect milk production, only the daily milk weights were taken, and no milk analyses were made.

In the cow experiments, the thyrolactin was given by mixing it with the grain at the afternoon feeding for three days in succession. Since certain cows refused to eat the material given in this way, because of its unfamiliar odor, the expedient was adopted later of mixing the thyrolactin with the grain feed, and then adding a small amount of molasses to the mixture. All cows ate the feed readily when given in this manner.

In certain of the trials, pulse records were taken, and milk samples were collected for a fat analysis; in the remainder only milk production records are available.

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RESULTS

The results of 5 trials in which 5 to 10 grams of thyrolactin were fed daily to 3 to 6 lactating goats are summarized in table 1. The results of a fourth trial in which U. S. P. desiccated thyroid was given instead of tyrolactin are included. Goat No. 836 had been lactating for about 14 months; the remainder of the animals were in the 2nd to 4th months of lactation at the beginning of the experiments.

TABLE 1

The effect of feeding thyrolactin on the milk production and heart rate of lactating goats

Date (1941)	Thyrolactin fed daily	Goat No.	Milk 5 days before thyrolactin feeding	Milk 5 days during thyrolactin feeding	Milk 5 days after thyrolactin feeding	Increase	Heart rate increase (beats per minute)
	grams		*lbs.*	*lbs.*	*lbs.*	%	
May 7–11	10	433	19.7	20.5	21.1	+ 7.1	+13.5
	5	843	4.9	5.7	6.9	+40.8	+18.2
	5	304	14.7	14.2	15.2	+ 3.4	+ 5.5
June 2–6	10	433	19.0	18.0	21.0	+10.5	+ 6.4
	10	943	6.4	6.0	7.4	+15.6	+14.4
	10	304	14.1	14.1	15.3	+ 8.5	+ 4.0
	10	437	14.1	14.0	14.5	+ 2.8	+ 7.1
	10	836	10.0	10.4	11.1	+11.0	+ 2.2
July 6–10	10	433	14.7	14.9	17.8	+21.1	+10.8
	10	843	6.6	6.2	6.8	+ 3.2	+ 8.8
	10	304	12.0	11.3	12.1	+ 0.8	+ 3.1
	10	437	12.7	12.8	13.6	+ 7.1	+ 1.0
	10	443	9.2	9.4	9.7	+ 5.4	+ 8.2
	10	836	10.2	10.7	11.2	+ 9.8	+12.0
						+10.51*	+ 8.2*
July 25–29 (des. thyroid)	10	433	16.4	16.0	16.7	- 1.8	- 3.0
	10	843	6.0	6.0	5.9	- 1.7	- 6.0
	10	304	11.6	12.3	10.5	- 9.5	- 4.0
	10	437	12.3	11.1	14.0	+12.1	- 9.0
	10	836	10.7	9.9	9.9	- 7.5	- 5.0

No. 836 had been lactating for more than a year. All other goats were in the second to fourth months of lactation.

* Mean.

It will be noted that the extent to which milk production was stimulated was quite variable, but there was a significant increase in milk yield in most cases. Comparisons of the milk yield for the five days preceding the thyrolactin feeding with the 5-day yield subsequent to the feeding period show increases in production ranging from 0.8 to 40.8 per cent, with an average increase of 10.51 per cent. There were also increases in the heart rate ranging from 1.0 to 18.2 beats per minute and averaging 8.2 beats per minute.

Five of the goats that had previously been used for the thyrolactin experiments were given a rest of two weeks, and then were fed U. S. P. desic-

cated thyroid at the rate of 10 grams daily. One goat responded with an increase of 12.1 per cent in milk production; two goats showed no change; and production of the remaining animals decreased 9.5 and 7.5 per cent, respectively. The heart rates actually showed a slight decrease. It is believed, however, that this is not due to any depressing effect of the thyroid substance, but that the decline in pulse rate expresses the response to a change from high environmental temperatures at the start of the experiment to more nearly normal levels in the later stages. Thus the stimulating effect of thyroid substance on the heart rate was probably masked by environmental factors that showed an opposite trend. While the number of trials with desiccated thyroid is probably too small to warrant a final conclusion, it appears that thyrolactin has a greater effect on lactation than the particular samples of desiccated thyroid used. Extensive assays on guinea pigs have also indicated that the better preparations of thyrolactin have somewhat greater potency than this lot of desiccated thyroid. Since U. S. P. desiccated thyroid is standardized by its iodine content, and not by biological assay, it cannot be predicted whether or not this relationship would hold with other lots of thyroid substance.

The results of feeding thyrolactin in a total of 14 trials with nine different cows are summarized in table 2. The cows used in these experiments were in the 4th to 10th months of lactation, at which time, as shown by previous work with thyroid substance and thyroxine, they should be responsive to thyroidal stimulation. The thyrolactin was given only during a 3-day period, and the effects are measured by comparing the 3-day production preceding the feeding period to the 3-day production subsequent to the 3rd day of thyrolactin feeding. It will be noted that there was a slight rise in production during the feeding period. This is due to the fact (shown by the individual data) that evidences of increased production appear by the third day after thyrolactin feeding is begun. During the 3-day period following treatment with thyrolactin, there was a significant rise in milk production in all except two cases, ranging from 6.09 to 22.6 per cent and averaging 8.59 per cent.

Unfortunately, it was not feasible to collect milk samples for analysis in all of the experiments. However, in the six trials in which milk fat analyses were made, there were pronounced rises in fat test in two cases and no appreciable change in the other four. The trials of Experiment II were made during the very hot weather of July at a time when normal fat tests fluctuated considerably in most cases, making comparisons difficult. Despite this fact it is believed that the 16.5 per cent rise in fat test and increase in fat yield of 26.8 per cent for cow No. 750 is significant, since in this case the milk fat percentage showed a steady and gradual rise as a result of stimulation with thyrolactin.

Cow No. 762 showed an increase of only 1.62 per cent in milk production,

TABLE 2

The effect of feeding thyrolactin on milk production, milk fat percentage, and milk fat production of dairy cows

Cow No.	Month of lactation	Milk production				Average milk fat percentage				Milk fat production				Remarks
		3 days before thyrolactin feeding	3 days during thyrolactin feeding	3 days after thyrolactin feeding	Gain or loss	3 days before thyrolactin feeding	3 days during thyrolactin feeding	3 days after thyrolactin feeding	Gain or loss	3 days before thyrolactin feeding	3 days during thyrolactin feeding	3 days after thyrolactin feeding	Gain or loss	
		lbs.	*lbs.*	*lbs.*	%				%				%	
Experiment I (run in May; 100 grams of thyrolactin from lot 36 fed daily)														
762H	4th	153.1	159.2	155.6	+ 1.62	3.26	3.72	4.13	+26.7	5.001	5.920	6.428	+28.50	
Experiment II (run in July; 100 grams of thyrolactin from lot SS fed daily)														
750H	4th	121.1	125.0	131.5	+ 7.90	3.15	3.13	3.67	+16.5	3.814	3.957	4.838	+26.84	
455G	6th	50.6	50.9	54.3	+ 6.72	5.21	5.15	5.22	.....	2.715	2.674	2.915	+ 7.36	Ate full dose only 1st day
926J	5th	68.3	68.1	73.1	+ 8.49	5.71	5.12	5.86	+ 2.63	3.920	3.480	4.286	+ 9.34	
921J	5th	58.6	60.3	63.6	+ 8.53	4.83	4.63	4.68	− 3.08	2.832	2.797	2.984	+ 5.37	Refused feed 2nd day
857J	6th	92.0	89.9	99.6	+ 8.26	4.73	4.78	4.63	− 2.12	4.353	4.344	4.615	+ 6.02	
Experiment III (run in September; 100 grams of thyrolactin fed daily)														
750H	6th	97.8	97.8	105.1	+ 7.46									
455G	8th	34.5	34.1	36.6	+ 6.09									Thyrolactin mixed with molasses
926J	7th	41.6	45.1	45.3	+ 8.89									
921J	7th	39.4	40.3	44.4	+12.69									
857J	8th	51.8	48.4	52.4	+00.11									
Experiment IV (run in February; 100, 75, and 50 grams respectively of thyrolactin from lot 36 fed daily)														
889J	6th	36.6	39.9	40.7	+11.20									
923J	10th	38.9	40.8	47.7	+22.60									
738H	7th	100.0	100.8	109.7	+ 9.70									
Mean					+ 8.59				+ 6.77				+13.90	

but her fat test increased 26.7 per cent, resulting in an increase of total fat yield of 28.5 per cent. So far as is known, no unusual environmental factors came in to influence this result.

The average daily milk production obtained in the 14 individual trials included in this report as well as the average heart rate in four trials is pictured in figure 1. Milk production began to rise on the third day of thyrolactin feeding, and then, even though no further thyrolactin was given, continued to rise for three days more. This was followed by a gradual decline in production to somewhat below the base level as the effects of the stimulation wore off. Even though heart rates were obtained on only four

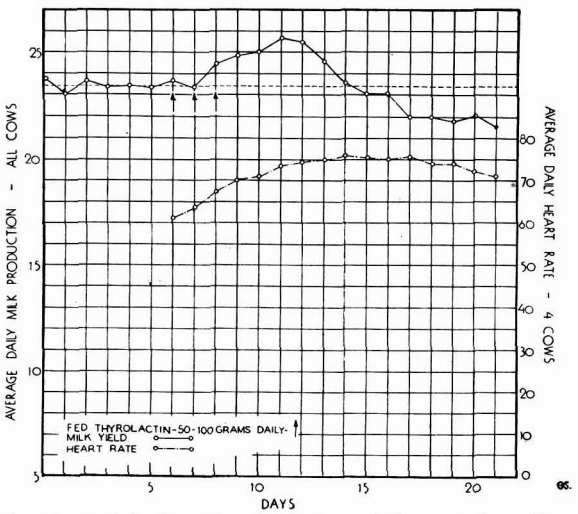

FIG. 1. The effect of feeding thyrolactin for a 3-day period on the milk production and heart rate of lactating cows. Thyrolactin was fed at the rate of 50 to 100 grams daily per cow.

cows, the average of these values shows a very uniform trend, rising parallel with the milk yield. The heart rate was maintained at an elevated level for about two weeks, whereas milk production dropped to normal within a week after the thyrolactin was discontinued.

DISCUSSION

The experiments reported herein clearly demonstrate that optimally iodinated milk proteins will stimulate increased milk production when fed for short periods to lactating cows and goats. When thyrolactin was fed to goats at the rate of 5 to 10 grams daily for a period of five days, there was an average increase in milk production of 10.5 per cent. The feeding of 50 to 100 grams of thyrolactin daily in 14 individual trials on nine different cows resulted in an average increase in milk production of 8.59 per cent.

In the six cases in which fat tests were obtained on the milk there was an average increase of 6.77 per cent in fat test and 13.9 per cent in fat yield. From these results it appears warranted to conclude that insofar as the stimulation of milk production is concerned, thyrolactin has all of the properties of desiccated thyroid or thyroxine as first reported by Graham (2, 3) and confirmed and extended by Jack and Bechdel (6), Folley and White (1), Herman, Graham and Turner (4), and Ralston *et al.* (7).

The percentage increases in milk and fat production are somewhat less than reported by previous investigators following the injection of thyroxine or the feeding of desiccated thyroid. However, since the response to be obtained following thyroidal stimulation is roughly proportional to the dosage, greater increases could in all likelihood be obtained by feeding larger amounts of thyrolactin.

In view of the results obtained it appears that the feeding of thyrolactin shows considerable promise as a means of stimulating increased milk production in lactating dairy cattle. It is true that most of the experiments conducted to date on the thyroidal stimulation of lactation in dairy cattle have been run over relatively short periods of time, and so might not reflect the true effect that would be obtained under practical feeding conditions. However, it was shown by Herman *et al.* (4) that the feeding of thyroid even at the peak of lactation tended to prevent the normal decline in milk production. A second feeding period during more advanced lactation resulted in a sharp rise in both milk and fat yield. Ralston *et al.* (7) demonstrated that lactating cows will respond to the injection of thyroxine with increased yields of milk and butterfat at all stages of lactation, though the greatest responses were obtained during the period of declining production. Hurst (5) reported that when 10 to 15 mg. of thyroxine were injected daily for a period of four weeks, milk production was maintained and in some instances there were sharp increases of as much as 38 per cent in milk yield. The yield of milk fat was increased even more than milk production. The injection of thyroxine into a single cow for five months increased her persistency index from an average of 91 per cent in the first six months of five previous lactations to 95 in the first six months of the experimental lactation.

Though the present experiments might be criticized from a practical standpoint because of their short duration, it is believed on the basis of the work cited above that the beneficial effects of thyrolactin feeding could be maintained throughout the lactation period. The initial results on long time experiments which are now in progress in this laboratory (unpublished) would tend to support this view. It is probable that with continued feeding of thyrolactin the desired result can be obtained with a considerably lower dosage than that used in the present experiment.

It is not within the scope of this paper to discuss the chemical problems

concerned with the formation of thyroidally active substances. For a review of this question the reader is referred to the report of Reineke, Williamson, and Turner (9). It may be well to point out, however, that in order to produce iodoproteins with satisfactory thyroidal activity it is necessary to carry out the process within rather narrowly defined conditions. While iodine can be combined with proteins by a variety of methods, the mere fact that a protein contains organically combined iodine, even though the total iodine is present in the same amounts as in thyroidally active preparations, is no guarantee of its potency. It is recommended, therefore, that iodoproteins to be used for the stimulation of lactation be produced by well controlled methods that are proved to give satisfactory results, and further, that they be assayed biologically before being put to extensive use.

SUMMARY

1. Optimally iodinated milk proteins (thyrolactin) were fed to lactating goats and cows and its effect on milk production was noted.

2. When fed to goats in declining stages of lactation at the rate of 5 to 10 grams daily, thyrolactin stimulated increases in milk production ranging from 0.8 to 40.8 per cent and averaging 10.51 per cent. The heart rate was accelerated an average of 8.2 beats per minute.

3. Thyrolactin fed in amounts of 50 to 100 grams daily to nine cows in a total of 14 individual trials caused an average increase in milk yield of 8.59 per cent. The individual increases ranged from 6.09 to 22.6 per cent. In six trials in which milk fat analyses were made there was an average increase of 6.77 per cent in fat percentage and 13.9 per cent in fat yield.

4. The results are discussed in relation to previous work that has been done on the effect of thyroid feeding and thyroxine injection, and the practical possibilities are pointed out.

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THE AVAILABILITY OF THE IRON OF COCOA AND OF IRON-FORTIFIED COCOA MIXTURES

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INTRODUCTION

Investigation has shown (1, 12, 17) that our national diet is more frequently deficient in iron than in any other mineral nutrient. To correct this situation two procedures are possible. The first is to improve the quality of the diet by educating people to consume foods known to be good sources of available iron. Such an undertaking moves slowly, however, and is handicapped by a lack of knowledge of the degree of availability of the iron of many foods. The second, and the present tendency, is to add the needed nutrient to commonly consumed foods. Chocolate and cocoa mixtures to be used in the preparation of chocolate milk are among the list of such iron-fortified foods.

Iron-fortification of foods is not always successful since free iron salts act as catalyzers in the oxidation of fats, thereby increasing oxidative deterioration. Cocoa and chocolate contain some natural antioxidants as evidenced by the fact that they protect natural flavors against oxidation (13). Therefore, foods such as chocolate and cocoa which are not readily subject to the development of rancidity are good carriers of added iron in so far as flavor is concerned. However, the mere addition of a desirable nutrient to a substance is no assurance that the added ingredient will remain available. The presence of tannic substances and phosphorus in cocoa suggests the possibility of removal of the iron by the formation of insoluble salts, which may make chocolate and cocoa unsatisfactory as carriers of added iron.

The total iron of cocoa and chocolate may be no more than 14.3 and 3.28 milligrams per hundred grams (11) respectively. However, the consumption of these products, whether fortified with iron or not, is great enough to make them an important source of iron, provided it is all available.

Because little is known about the nutritive value of the iron in cocoa, whether natural or added, this study was undertaken.

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GENERAL PLAN OF STUDY

The purpose of this study was accomplished by measuring the degree of hemoglobin regeneration in anemic rats when cocoa and iron-fortified cocoa were fed at the same level of iron intake as an inorganic salt of iron. An attempt was made to check the results by the chemical procedure of Hill (9), but because of color interferences, this had to be abandoned. Since comparatively little is known about the tannic substances in cocoa, their influences were studied by the use of pure tannic acid.

EXPERIMENTAL

In determining the nutritional value of the iron of cocoa and iron-fortified cocoa a modification of the Elvehjem and Kemmerer (5) technique was followed. White rats of the Battle Creek strain were used in this experiment. Before weaning, the young rats had access only to whole milk powder (6) and distilled water in addition to the mother's milk. They were weaned at three weeks and at this time were placed in individual galvanized iron wire cages which rested on raised screening of three mesh to the inch. The rats were fed dried whole milk *ad libitum* in porcelain cups. In accordance with the recommendation of Smith and Otis (16), when the animals were twenty-eight days old, they were given 0.05 milligrams of copper as the sulphate to insure depletion of the iron stores in the liver and 0.04 milligrams of manganese as the chloride. The rats were weighed weekly and as soon as the subjective signs of a developing anemia were evident, weekly hemoglobin determinations were made. The Newcomer method with a Klett

TABLE 1

Feed formulas used

Ingredient	Group I	Group II	Group III	Group IV	Group V	Group VI
	%	%	%	%	%	%
Whole milk powder	54.0	54.0	54.0	54.0	54.0	54.0
Cocoa	14.0	.....	.....	14.0	.....	.....
Sugar	32.0	32.0	32.0	32.0	32.0	32.0
Casein	.....	1.4	1.4	.....	1.4	1.4
Cornstarch	.....	8.7	7.0	.....	8.7	8.7
Crisco	.....	1.6	1.6	.....	1.6	1.6
Tannic acid	.....	.....	1.7	.....	.....	.....
Iron intake per day per rat						
	mgms.	*mgms.*	*mgms.*	*mgms.*	*mgms.*	*mgms.*
Iron, from cocoa	0.19	0.00	0.00	0.19	0.00	0.00
Iron, from ferric chloride	0.00	0.19	0.19	0.11	0.30	0.00
Iron, total*	0.19	0.19	0.19	0.30	0.30	0.00

NOTE: Each rat in all groups was fed 0.05 mgms. of copper and 0.04 mgms. of manganese per day.

* The very small amount of iron in the whole milk powder (0.0008 per cent) is not included in the total.

colorimeter was used and the solutions were read against a standard Newcomer glass disk. After approximately forty-six days, when the hemoglobin values were between 3.5 and 4.5 grams per 100 cc. of blood the rats were considered sufficiently anemic to be used for a recovery experiment. At this time the animals were distributed as evenly as possible with respect to age, weight, and hemoglobin level into six groups. All groups contained equal numbers of both sexes and consisted of twelve animals each except the negative control group which consisted of ten animals.

Six diets were compounded as shown in table 1, and fed one to each of the six groups. These diets were approximately alike in nutrients and calories, but they differed in the source and amount of iron. The cocoa powder used (table 2) was chosen after analyses of eighteen commercial

TABLE 2

Analyses of cocoa powder

Constituents	Per cent
Moisture	5.40
Protein	22.62*
Theobromine	1.75
Caffeine	0.12
Fat	11.23
Fiber	5.25
Ash	5.98
Tannic substances	12.15†
Other N-free matter	35.50
Iron	0.0134‡

* Nitrogen (minus theobromine and caffeine nitrogen) × 6.25.
† Ulrich's method as modified by Kuzmeski and Mueller (unpublished results).
‡ Per cent of iron as total iron.

powders because of the high percentage of tannic substances (12.15 per cent) present. On a fluid milk basis the cocoa-milk diet would represent 3 per cent cocoa, 7 per cent sugar, and 90 per cent milk, and approximates chocolate milk with a maximum amount of cocoa. The whole milk powder was used instead of fluid milk because of obvious advantages in feeding. Group I received this ration plus the copper and manganese solution; and Group IV the same as Group I plus ferric chloride to raise the total iron intake to a level of 0.3 milligrams daily. Ten grams of each of these two rations were fed to each rat daily.

The whole milk powder rations were made up to simulate the cocoa ration in nutritive value. Casein replaced 38 per cent of the cocoa protein since only that percentage of cocoa protein is utilized by the rat. Neutral fat, uncontaminated with iron, replaced the cocoa fat, and starch was used to make up the carbohydrate and remainder of the protein fraction. No agar nor inert material was used to replace ash and fiber since this might interfere with absorption. Since these constituents were omitted, 9.7 grams

of these rations were fed daily, this amount being equivalent in nutrients and calories to ten grams of the cocoa rations. Experimental groups II, V, and VI received this ration plus copper and manganese. Groups II and V were positive control groups receiving 0.19 and 0.3 milligrams of iron daily as ferric chloride, and Group VI was the negative control group receiving no iron supplement.

The whole milk powder ration plus tannic acid was fed to Group III, and was similar to that fed Group II, except that pure tannic acid was added and a corresponding amount of cornstarch was omitted. This ration was also fed at the 9.7 grams daily level.

All mineral salts were fed in solution. During the depletion period, after the animals were twenty-eight days old, the copper and manganese solution was fed by pipette daily, six days per week. After the depletion period the mineral solutions were fed three times each week and were pipetted onto a small amount of the dry ration in a glass dish. The animals consumed it greedily the moment it was placed in the cage.

Weekly hemoglobin determinations and weighings were made throughout the experimental period which lasted for six weeks. During this time all animals were kept on an equivalent food intake. Preliminary investigation showed that approximately ten grams daily fed six days a week was the maximum which the animals could consume at the age when they were put on the experiment. Therefore, 10 and 9.7 grams per day, as explained in the discussion of the rations, were fed six days per week until the animals were seventy days old; after which time a seventh 10- or 9.7-gram portion of the basal ration was added weekly until the rats were sacrificed. This food allotment allowed substantial gains through the six-week period. Constant care was taken that all food was eaten and all animals which failed to consume the allotted portion were discarded. All animals continued to receive both copper and manganese during the experimental period; the copper to insure utilization of iron (7), and the manganese because investigation has shown that rats will thrive on a milk diet only if supplemented with copper, iron, and manganese (8).

RESULTS AND DISCUSSION

The average hemoglobin responses and weight gains of all groups during the six-week experimental period are given in table 3. Both males and females are included in the averages because sexes were equally divided and also because the separate analysis of data showed no significant difference between sexes. Results indicate that the iron of cocoa is not so well utilized as an equivalent amount of iron fed as ferric chloride. Group I, receiving cocoa as a source of iron regenerated 5.3 grams of hemoglobin per 100 cc. of blood; while Group II, receiving the same amount of iron as ferric chloride regenerated 8.4 grams during the six weeks of the experimental

period. Thus, the iron of cocoa regenerated approximately two-thirds as much hemoglobin as an equivalent amount of ferric chloride. The fact that Group III regenerated the same amount of hemoglobin as Group II, indicates that the addition of tannic acid did not decrease the utilization of iron. In fact the rapid regeneration of hemoglobin in this group during the first three weeks of the experiment might indicate that the presence of the tannic acid favored the rapid absorption of iron during the early part of the period (3). It may be that the water-insoluble iron tannate was made utilizable by gradual solution in the digestive fluids (2).

TABLE 3

The average age, weight, and hemoglobin regeneration of six experimental groups of anemic rats

Group No.	Ration fed*	Iron in ration*	Initial age	Initial weight	Weight after 6 weeks	Gain in weight	Hemoglobin in grams per 100 cc. blood		
							Initial	After 6 weeks	Total gain
		mgms.	*days*	*gms.*	*gms.*	*gms.*			
I	Milk plus cocoa	0.19	46	85	137	52	3.8	9.1	5.3
II	Milk plus iron	0.19	46	90	161	71	3.8	12.2	8.4
III	Milk plus iron plus tannin	0.19	49	99	158	59	4.2	12.5	8.3
IV	Milk plus cocoa plus iron	0.30	48	88	133	45	3.9	12.2	8.3
V	Milk plus iron	0.30	46	91	158	67	4.0	13.3	9.3
VI	Milk	0.00	46	87	145	58	4.0	5.4	1.4

* For complete information see table 2.

The results show that when the cocoa-milk ration was fortified with iron, the added iron was just as available in the presence of cocoa as when added to a whole milk ration. Addition of 0.11 milligrams of iron daily, which increased the daily intake to 0.3 milligrams, permitted Group IV to regenerate 8.3 grams of hemoglobin per 100 cc. of blood as compared with 5.3 grams when cocoa was not fortified. Group V, receiving the same level of iron as Group IV, but all of it in the form of an iron salt added to the milk ration, regenerated 9.3 grams of hemoglobin. This is an increase of 1.0 gram over that produced on an intake of 0.19 milligrams of iron. The difference in these gains is in the order of magnitude to be expected on the basis of utilization of cocoa iron observed for Groups I and II. The hemoglobin gain of Group IV receiving cocoa plus ferric chloride is almost identical with that of Group II, receiving 0.19 milligrams of iron as the ferric

salt daily. Therefore, it may be concluded that Group IV must have received an equivalent amount of utilizable iron; that is, 0.11 milligrams derived from the inorganic salt, the remainder from the cocoa.

The fact that an addition of 0.11 milligram of iron daily produced an increment of gain in hemoglobin of 3.0 grams in Group IV and of only one gram in Group V may seem inconsistent. This difference may be explained, however, by the fact that there is a lowering in the degree of efficiency with which the animal body utilizes iron as the amount of available iron increases. Hemoglobin gains are greater in proportion to the amount of iron fed at the lower levels of iron intake (15). In Group II the level of iron before enrichment was nearly sufficient for complete regeneration (4). However, because the iron of cocoa is not as well utilized as an equivalent amount of inorganic iron and the level fed before enrichment was below that necessary for complete regeneration, the added increment was used more efficiently. Thus it is possible to conclude that the added iron was all utilized.

Groups II and V had average weight gains of 71 and 67 grams during the six weeks of the experimental period. The four-gram difference is insignificant. However, Groups I and IV, receiving the cocoa rations, and Group III, receiving the tannin ration gained but 52, 45, and 59 grams respectively during the same period. Negative controls (Group VI) grew slightly better even than those receiving cocoa, indicating that cocoa is detrimental. These findings are in line with those of other workers. Lease and Mitchell (10) found that levels of tannic acid greater than five per cent retarded rate of growth of white rats. Mueller and Ritchie (14) report that four per cent of cocoa in a mineralized milk ration definitely retarded growth in white rats. However, since the animals used in this study were anemic, and food intake was restricted, growth data are not as striking as they might be under other circumstances. It was also noted that hard, dry feces appeared in all rats soon after cocoa feeding was started in spite of the usual tendency to diarrhea on milk rations.

The effect of the tannic substances in cocoa on the availability of iron in cocoa is not conclusively determined by this study. Tannin added in the form of tannic acid did not reduce the availability of iron in a milk diet. It should be pointed out that tannic acid may not have the same effect on the utilization of iron as the tannic substances which are present in cocoa, about which little is known. The nature of the iron-containing compounds in cocoa needs to be determined before it can be stated that any specific substance is responsible for reducing the availability of cocoa iron to the animal body. The tannins of cocoa do not appear, however, to reduce the availability of iron added to enrich the cocoa mixture. It appears that foods containing cocoa and chocolate are well suited to be fortified with iron: first, because the added iron remains completely available; and second, because

cocoa contains some natural antioxidants which retard or prevent the oxidation of the fat in the presence of catalyzing iron salts.

SUMMARY AND CONCLUSIONS

1. The availability of the iron of cocoa and iron-fortified cocoa has been determined by biological procedure.

2. The iron of cocoa regenerated approximately two-thirds as much hemoglobin as an equivalent amount of ferric chloride.

3. Approximately two (1.7) per cent of pure tannic acid did not reduce the availability of the iron added to a milk ration.

4. Iron added to a cocoa mixture was completely available, indicating that the factor which limited the availability of the iron of cocoa had no influence on added iron.

5. The fortification of cocoa or chocolate milk with iron may be warranted on the basis of the availability of the added iron and on the antioxidants which retard or prevent rancidity development in the presence of iron.

6. The indiscriminate use of chocolate and cocoa in milk is not recommended because of the yet unexplained effect of cocoa on growth and intestinal function.

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THE CURD NUMBER TEST. A METHOD OF TESTING THE CURDLING QUALITIES OF MILK*

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Cow's milk coagulates when taken into the human stomach. Small soft curds such as those formed from boiled milk are considered to throw less of a strain upon digestive functions and to be more readily tolerated than are the large bulky curds of raw or pasteurized milk (1, 3, 4). For investigation of the curdling properties of milk the laboratory technique most widely used at this time is the curd tension test (7, 9), which measures the toughness of the clot which forms when milk is made to coagulate under certain prescribed conditions. In this test the only variable permitted lies in the milk itself, the framework of test conditions being frozen into a rigid routine, and deviations from the prescribed directions yield undependable results. The present paper records: a fresh approach to the investigation of coagulation of milk in the human stomach by presenting a device for reproducing more closely the actual happenings within the stomach than does the curd tension test; a standardized procedure for preserving and measuring the curds which form; an empirically derived scale for indicating the curd size distribution and discussion of the results obtained. This technique utilizes the apparatus originally developed by Chambers and Wolman (2), but with an improved routine of operation and a new system for calculating index numbers or "curd numbers." The successive steps which led to the crystallizing of the test procedure into its final somewhat arbitrary form and the reasoning which lies behind the more important features are included in the presentation.

THE CURD NUMBER TEST

Apparatus: The curdling of the milk takes place within rubber bags which hang in a water bath (fig. 1). This bath measures $30 \times 20 \times 10$ inches, and is lined with copper. Six inches of water, maintained at a temperature 37° and 37.5° C. by a thermostat-controlled heat coil are kept in it during operations. Across the top of the tank run two bars studded at equidistant intervals with metal clips that hold short tubular glass cylinders from which the bags are suspended. These cylinders, open at both ends, measure 2 cm. in diameter and 7 cm. in length and are made with a rimlike lip at the lower end. The bags are of thin rubber latex (fig. 2). One and one-half inches above the floor of the tank hangs a tray-like platform divided into slotted

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troughs by copper strips. Each trough measures 8 × 24 in., and receives the rounded tip of a milk-filled bag. The platform is suspended at each end by a center pivot connected by rocker arms to an eccentric gear driven by an electric motor. When the machine is in operation the platform rocks back and forth about 30–40 times per minute, and imparts gentle rhythmic agitation to the contents of the bags, the rate of oscillation of the platform being controlled by an adjustable rheostat.

Operation: At the start of an experiment the open mouths of a series of bags are fastened by rubber bands to the lower ends of the glass cylinders.

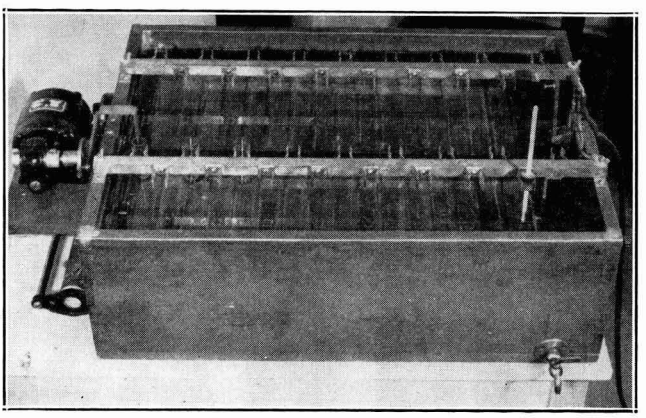

FIG. 1. Apparatus used in the artificial coagulation of milk preparations. Note the water level, the slotted tray at the bottom, the rheostat-controlled motor and the peripheral heating coil. The spigot at the lower end is for emptying the tank.

Nine bags are filled with each type of milk being tested. One hundred ml. of milk are placed in each, and the height of the cylinder adjusted so that the fluid levels inside and out coincide without undue tension being thrown on the rubber walls of their submerged portions. Generally speaking, the bags have about four-fifths of their substance submerged. The empty upper fifth collapses and lessens surface evaporation. When the temperature of the contained milk has risen to that of the water bath, the platform is set in motion. A measured amount of coagulating solution (2–4 ml. N/1 hydrochloric acid, as much as is necessary to produce the desired pH, as shown by a preliminary titration, plus 3 ml. of a solution of 0.6 per cent commercial pepsin powder U.S.P.) is introduced by gravity from a pipette. Coagulation of the milk is observed to take place within the first few minutes. Agitation of the bags is continued for thirty minutes. At fifteen minutes they are shaken for a moment in order to assure uniform distribution of the coagulant. The bags are next emptied in groups of three into 16-oz. glass jars containing 30 ml. of formalin (40 per cent formaldehyde solution), or

individually into 4-oz. jars containing 10 ml. of formalin. After being hardened from 24 to 72 hours, or indefinitely longer, the jar contents are washed through a battery of three 8-inch sieves, of mesh sizes 1/2 in., 1/10 in. and 1/100 in., by means of a stream of flowing tap water. The heaps of curds thus selectively screened are transferred to previously weighed filter papers, and spread out to dry on wire screens at room temperature (fig. 3). After

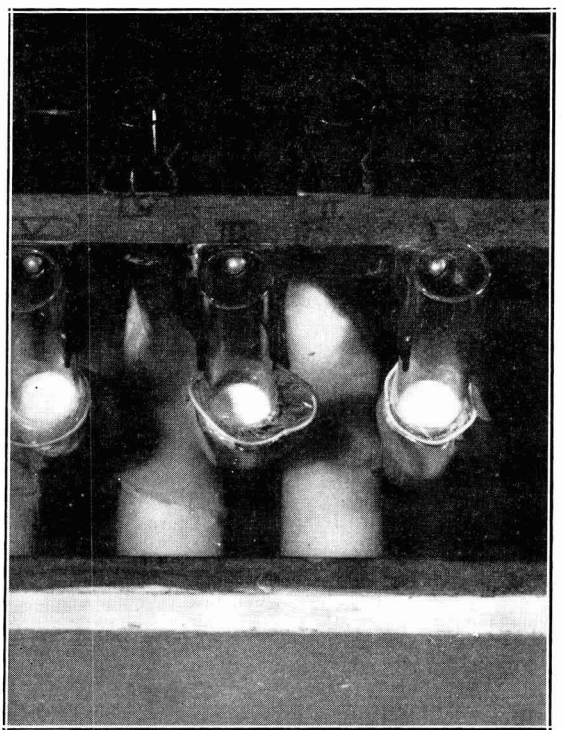

FIG. 2. Close-up of the glass cylinders to which are attached the filled rubber bags. The milk has not yet coagulated. The bags are rhythmically flexed as the supporting platform rocks to and fro.

two or three days the heaps of dried curds are then weighed individually to 0.01 gm.

Calculation: The following formula is then applied: $1a + 2b + 3c =$ curd number. (a = Percentage of total curd weight caught by the 1/2 in. sieve; b = Percentage of total curd weight caught by the 1/10 in. sieve; c = Percentage of total curd weight caught by 1/100 in. sieve.)

DERIVATION OF CONCEPT OF CURD NUMBER

The early studies on curd size measurement (2) employed 8 graded sieves of mesh sizes 1 in., ½ in., ¼ in., ⅛ in., 1/10 in., 1/20 in. and 1/100 in.

Commercially such sieves are referred to in terms of their reciprocals, as No. 1, No. 2, etc. Raw and pasteurized milks would yield large curds, to be caught by series No. 1 and No. 2, whereas with specimens of boiled or homogenized milk the first sieve to trap any curds would be No. 4, No. 6 or No. 10.

The original recommendation (2) was based upon the assumption that peptic digestion is a peripheral process, taking place only at the curd surface, and that for any given specimen of milk the speed of digestion by proteolytic enzyme is proportional to the total surface area of the curds. The

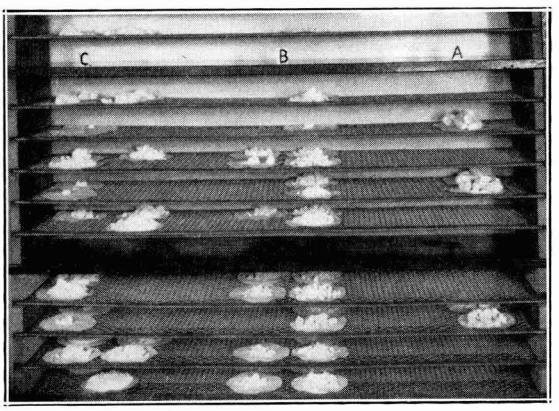

FIG. 3. Photograph of curds being dried on wire racks. Each horizontal row represents curds collected from 300 cc. of milk. Column A shows the large-sized curds caught by the 1/2 in. sieve, column B the medium-sized curds caught by the 1/10 in. sieve, and column C the masses of fine curds caught by the 1/100 in. sieve. The "abc" milks depicted here are raw and pasteurized samples, whereas the "bc" types shown are assorted homogenized and boiled preparations. (See text.)

total surface area[1] expressed in square centimeters or similar units might thus be taken as an expression of the availability for digestion of the milk in question. In such a system of calculation several additional assumptions became necessary. All curds were considered to be solid, spherical and smooth-surfaced, the measured breadth of each individual sieve opening was taken as

[1] The formula was derived as follows:

$$\text{volume} \times \text{specific gravity} = \text{weight}$$

$$\text{volume} \times 3/r = \text{surface area}$$

$$\frac{\text{weight}}{\text{specific gravity}} \times 3/r = \text{surface area}$$

$$A = \frac{100 \times 3}{a \times 1.2}\left(\frac{a_1}{r_1} + \frac{a_2}{r_2} + \ldots + \frac{a_r}{r_n}\right) = \frac{250}{a}\left(\frac{a_1}{r_1} + \frac{a_2}{r_2} + \ldots + \frac{a_n}{r_n}\right)$$

A = Total surface area of 100 gm. of curds.

a = Total curd weight.

1.2 = Approximate specific gravity of milk curds.

$a_1, a_2, \ldots a_n$ = Total weight of curds from each sieve.

$r_1, r_2, \ldots r_n$ = Radius of curds from each sieve.

the true measure of diameter, and all curds caught on any one sieve were assumed to be of the same diameter. The surface area of 1 gm. of fine curds caught on the No. 100 (1/100-in. mesh) sieve would calculate out as being 10 times greater than that of 1 gm. of curd trapped on the No. 10 (1/10-in. mesh) sieve, and 100 times greater than the same amount caught on the No. 1 (1-in. mesh) sieve.

The practicability of total curd surface area as an indicator of curd size was tested out thoroughly, being computed in hundreds of determinations. This system of computation not only proved involved, slow and cumbersome, but failed on many occasions to give consistently reproducible results with identical specimens of milk.

Minor fluctuations in the weight of curds on the finest sieves—deviations within the range of error of the experiment—would exert a disproportionate effect on the total value computed for the milk. Thus, for example, a milk sample might yield one or two large coagula unable to pass the No. 2 sieves but have the remaining curds so small as to be caught only by the No. 40 and No. 100 sieves; for this milk the total surface number by virtue of the great number of small particles would calculate as high or even higher than would a different milk specimen which yielded a mass of medium-sized curds of more or less uniform size. This was probably the reason why, when comparing milks one with another, the curd surface area figures often failed to show any consistent correlation with the curd tension values for the same milks. Other workers (10, 11) have recently reported similar discrepancies.

After exploring other possible systems of computation with equal lack of success, the problem of providing a sound practical index for the curdling behavior of milk was approached from the angle of *curd size* alone. The absolute number of sieves was first reduced from eight to three in order to simplify the manipulations and calculations. Thus the No. 1 sieve was eliminated and all curds caught by No. 2 were considered "large." The No. 4 and No. 6 sieves were removed and all curds which would pass No. 2 but were caught by No. 10 were considered "medium-sized." The No. 20 and No. 40 sieves were also dropped and No. 100 was retained to catch those "fine" curds which passed sieve No. 10. Then, by referring to the large curds as "a," to the medium-sized as above described as "b" and to the fine ones as "c," it was possible to establish a crude but practical system for characterizing the curds formed from milks. Raw and pasteurized milks were found to have an appreciable proportion of curds of each type, and hence could be termed "a-b-c" milks (fig. 3). Boiled or thoroughly homogenized milks yielded curds of b and c size only ("b-c" milks) whereas human milk with its very fine curds fitted into the "c" milk class. Furthermore it was feasible to graph or chart the distribution of the a, b, and c component into what might be called an "a-b-c diagram."

This "diagram" technique proved useful in presenting the effect of

simple influences on a given sample of milk. For example, when milk was heated to 180° F. and held for various lengths of time at that temperature the plotted data showed a progressive decrease in the height of the "a" column while the height of the "c" column became steadily more elevated (fig. 4). The raw sample might be described as 80 per cent a, 14 per cent b, and 6 per cent c, whereas when the same milk had been heated at 180° F. for 60 minutes the schema became 0 per cent a, 51 per cent b, and 49 per cent c. By connecting the left corner of each rectangle representing the percentage weight of curds of a, b, and c size the typical diagram could be obtained.

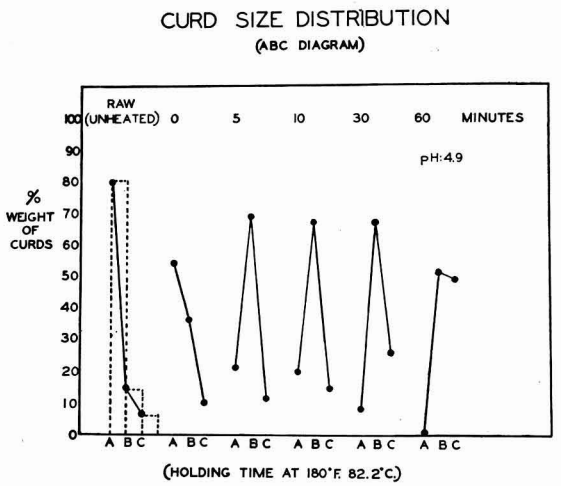

FIG. 4. Diagram showing changes which take place in curdling "a-b-c" properties as a specimen of raw milk is kept warm at 180° F. for progressive periods of time. The percentage weight of a-sized curds gradually grows smaller, and finally disappears in 60 minutes, whereas the percentage weight of c-sized curds steadily mounts until nearly 50% of the total weight of the curds is of the fine variety. (For discussion see text.)

This simple a b c system was useful with small series of specimens but proved too cumbersome when large numbers of milk samples were being codified and compared. For such circumstances it seemed essential to replace the three factor equation with a single figure, such as might be secured if the three units of the a b c code were multiplied by arbitrarily chosen factors and then added together. If the higher factors were linked to the smaller sized curds, then the smaller the average curds, the greater the "curd number."

Many different sets of incremental factors were tried out empirically in order to find the simplest which would express clearly the changes in curd size obtained when milks were modified. The simple arithmetical series 1, 2, 3 proved very satisfactory and gave dependably reproducible results. When

"a" is multiplied by 1, "b" by 2, and "c" by 3, the final total increases steadily as the percentage of small curds increases:

$$1a + 2b + 3c = \text{curd number}$$

The lower limit of this schema would be found in a milk having all the curds of "a" size: $a = 100$, $b = 0$, and $c = 0$; curd number = 100. The maximum curd number would be obtained when all curds were "c" curds: $a = 0$; $b = 0$, and $c = 100$; curd number = 300.

FACTORS AFFECTING ACCURACY OF RESULTS

Fragility of Curds: Freshly formed curds are friable and easily broken. In their transfer from rubber bags to jars all manipulations must be slowly and gently performed.

Hardening: Of the various preserving agents used in pathological laboratories, 10 per cent formalin was discovered to be the most satisfactory. It is cheap and readily available, stops instantaneously the enzymatic hydrolysis of the milk, preserves the natural shape and color of the curds, does not dissolve out the contained fat droplets, and renders the curds sufficiently firm to withstand the manipulations of sieving and washing without becoming fragmented. It does give rise to some slight shrinkage of the curds, but all sized ones are equally affected so that no disturbance in their relative proportions is produced. It precipitates the globulins from the whey in the form of delicate floccules which are washed through the No. 100 sieve and therefore do not interfere with the calculations. The greatest disadvantages of formalin lie in its odor, which makes it necessary to use a well-ventilated room for drying purposes (though not necessarily one separate from the main laboratory), and in its tendency to cause irritative dermatitis. The technician handling the curds during washing and weighing should wear rubber gloves.

Washing: At first (2) each sieve with its contained curds was weighed immediately following washing, and then the figure for the sieve itself when wet but empty was deducted. It was soon discovered, however, that adsorbed water was a source of appreciable error, adherent moisture being much more abundant on the fine mesh sieves with their small curds than on the coarser sieves with their larger more separated coagula. Not until the steps of transferring the curds to filter paper and permitting them to dry out were adopted could reproducible trustworthy figures for total weight be obtained. Again, the time-consuming step of filtering the wash water from the 1/100-in. sieve was eliminated because the trapped thin film of coagulated formalin-precipitated lactalbumen stippled with casein grains had a negligible weight when dried.

Drying: Before being washed and hardened, curds, following washing and sieving, are spread upon filter papers to dry out at room temperature. Regardless of size all curds seem to lose water at a uniform rate as illustrated

in table 1. Daily checks show a gradual loss of weight to a constant level, followed shortly by a slow steady gain. The humidity of the room air plays a role in the rate of drying, and curds weigh a little more on damp days, but no selective influence of humidity upon curds of different sizes becomes apparent. Therefore, since all comparisons are relative, and since the "curd number" calculation is based upon percentage distribution of weights, it is not necessary to wait for the drying curds to reach constant weight before weighing them. After three days the surface moisture will have evaporated, and the filter papers themselves will have become thoroughly dry. In practice the weights are taken usually after three days of drying.

TABLE 1

Constancy of "curd number" as related to water content of curds

Specimen number	Date of washing	Date of weighing	Total weight of curds (a + b + c)	Calculated curd number
	Aug. 4	Aug. 7	20.873	280
	"	" 8	20.970	280
	"	" 9	20.898	280
	"	" 10	20.875	280
111A	"	" 12	20.022	280
	"	" 13	21.062	280
	"	" 14	21.041	280
	"	" 15	21.704	280
	Aug. 13	Aug. 15	31.859	106
	"	" 16	26.943	106
144	"	" 19	25.919	107
	"	" 22	25.026	107
	"	" 23	25.242	107
	Aug. 13	Aug. 15	34.072	106
	"	" 16	28.285	107
145	"	" 19	25.368	108
	"	" 22	25.422	108
	"	" 23	25.561	108
	Aug. 13	Aug. 15	45.141	101
	"	" 16	33.713	102
169	"	" 19	25.120	103
	"	" 22	24.244	103
	"	" 26	24.304	103

Content of Pepsin: The strength of the 0.6 per cent granulated pepsin solution recommended for the curd number test has been found to be equivalent to about 16 mgm. of rennin per ml. The milk-coagulating power of gastric juice as determined in a large group of children (12) when measured by the Helmer-Fouts method (6) has been found to range in strength between 0 and 100 mgm. of rennin per ml. Therefore, when 2 ml. of the artificial solution is added to 100 ml. of milk in the performance of the test one utilizes a standard set of circumstances which does not deviate too abnormally from intragastric conditions occurring in the young child or infant. The concentration of pepsin used, within physiologic limits, exerts but a

minor influence on "curd number," as is shown by data obtained with increasing strength of added pepsin, all other circumstances being kept constant:

Pepsin	6%	0.6%	0.06%
Curd number	243	234	229

Thus within the physiologic range, increase of pepsin concentration tends to increase the curd number slightly.

Hydrogen-Ion Concentration: The effective factor in the acidity of gastric juice as regards milk coagulation is the hydrogen ion. Neither the nature nor the valence of the anion is of importance. Experiments with different acids in the coagulating fluid, namely hydrochloric acid, citric acid, sulphuric acid and lactic acid, have shown the curd number to be constant for each milk so long as the pH is the same.

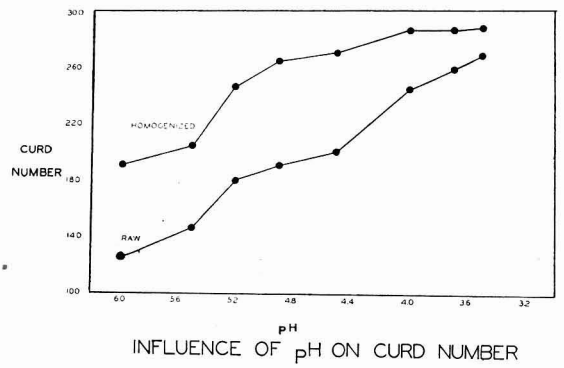

FIG. 5. Diagram showing the influence of hydrogen-ion concentration on the "curd numbers" of two specimens of milk from the same original batch. Although the curd number of the homogenized milk is consistently smaller than that of the unprocessed variety, both show a uniform rate of rise as the pH falls. Determinations cannot be safely made below pH 4.0 because the destructive proteolysis of the pepsin becomes active at this level. The unevenness of the curds is a manifestation of the range of experimental error. The homogenized milk was prepared from the raw milk.

In the first studies from this laboratory the determinations were carried out at a pH of 4.9 because of the impression that this state of acidity represented the average value for the infant's stomach. More recently obtained data (12), however, demonstrate that following ingestion of milk coagulation in the stomach takes place usually at a pH between 5.0 and 6.0, even in young adults. For all current tests on milk, therefore, pH 5.5 has been selected except for special cases.

The hydrogen ion concentration at which milk coagulates bears a direct relationship to the size of the curds which form. As the concentration grows stronger the curds become smaller. This phenomenon is illustrated in figure 5, in which the curd numbers for raw and homogenized milk from the same

source have been plotted. The curd number for the raw milk at pH 6.0 (123) was close to the minimal value obtainable (100), indicating that these curds were very large. The number for homogenized milk (190) signifies that the curds were largely of medium size. With increasing acidity the curd numbers become less widely separated as they approach the maximum figure (300).

It is not feasible to carry studies on the effect of hydrogen ion concentration below pH 4.0, since with stronger concentrations of acid the pepsin in the coagulating fluid becomes activated, and the proteolysis during the period which ensues causes significant destruction of the coagula.

Temperature of Coagulation: In the small range of human body temperatures for health or disease (36°–41° C.) the curdling behavior of milk showed no great changes. For the curd number technique normal body temperature (37° C.) has been selected.

Technique of Mixing: Immediately after adding the coagulating solution to the bag containing the milk the operator must agitate the mixture in order to obtain thorough and uniform contact between the two liquids. A second manipulation halfway through the test, at 15 minutes, proves necessary also. This must be performed in such fashion that breaking of the formed curds is avoided. In the absence of thorough mixing wide differences in curd formation were encountered among bags filled with portions of the same milk.

Three methods of manipulation of the bags for mixing purposes have been investigated: (a) gentle hand squeezing, (b) holding the ends of each bag between the fingers and moving the contents to and fro in the longitudinal axis, and (c) slipping a slender rubber tube to the bottom of the bag and blowing a stream of air bubbles from the lower end. The hand squeezing technique was found to fragment the coagula to an appreciable degree, as indicated by the high average curd number (table 2), whereas shaking produced this undesired effect less markedly, and the air bubble method least of all.

These three methods have been subjected to statistical comparison by the method of analysis of variance. On different days 15 specimens of pasteurized milk were tested by each of the three methods. With each method curd number was determined on 2 milks in duplicate, on 9 milks in triplicate, on 3 milks in 4-fold replication and on 1 milk with 6-fold replication. It is

Analysis of variance

Source of variation	Degrees of freedom	a (squeezing)		b (shaking)		c (bubbling)		F 5%	1%
		Mean square	F ratio	Mean square	F ratio	Mean square	F ratio		
Between milks	14	637.4	8.45	964.0	47.6	21.50	1.39	2.00	2.66
Within milks (error)	34	75.4	.....	20.3	.....	15.47	.....	.....	.....

evident that variation from milk to milk was small in method (c) and not significantly greater than the error. Method (b) showed the smallest error and is clearly superior to method (a). The variance of single curd number measurements with method (b) increases with the curd number and may be estimated as $\sigma = 0.76$ (curd number $- 100$). In the light of these considerations, and because the air-bubbling technique was time-consuming and cumbersome, method (b), that of gentle hand shaking, was selected as the recommended procedure for the mixing maneuver.

TABLE 2

Comparison of pasteurized milks processed by (a) squeezing, (b) hand shaking and (c) air-bubble technique at pH of 5.5

Date	No. of exps.	a		b		c	
		Curd Nos.	Aver. curd Nos.	Curd Nos.	Aver. curd Nos.	Curd Nos.	Aver. curd Nos.
5/1	6	120–120–124 132–140–141	130	103–104–104 104–106–108	105	113–114–115 116–118–121	116
5/2	2	106–108	107	104–107	105	106–108	107
5/5	2	131–136	133	117–120	118	103–105	104
5/9	3	155–167–173	165	130–136–141	135	122–125–131	126
5/15	3	116–118–134	123	118–123–128	123	114–116–123	118
5/27	3	130–133–146	136	117–122–122	120	127–135–136	133
5/29	3	132–144–152	137	108–109–112	109	119–119–127	122
5/30	3	130–144–152	142	147–153–159	153	115–117–118	117
6/2	4	134–140–144 147	141	127–128–128 136	130	108–111–112 116	112
6/3	4	131–134–143 151	139	120–120–122 128	122	115–116–124 124	120
6/5	3	119–121–137	126	112–115–124	117	104–105–106	105
6/9	4	136–142–144 158	145	155–155–163 169	161	121–121–126 130	125
6/10	3	140–159–164	154	137–138–148	141	112–119–122	117
6/24	3	156–164–171	164	122–124–132	126	118–120–126	121
6/25	3	129–132–134	132	108–111–113	110	102–103–105	103
Average			138.3		125.1		116.4

TABLE 3

Variance of curd number (shaking method)

	Curd number		
	100–120	120–140	140–180
Single measurements	±6	±10	±13
Duplicate measurements	±4	± 7	±10
Triplicate measurements	±3	± 6	± 8

Exactness of Results (Shaking Method): Table 3 shows the accuracy of measurement for test specimens of pasteurized milk, taking 5 per cent

fiducial limits. Since pasteurized milk rarely gives a curd number higher than 180, homogenized milk, which possesses a spread centering between 200 and 280, was taken to explore the exactness of the curd number method in the range between 180 and the maximum 300. Analysis of the data in a series of tests taking 5 per cent fiducial limits of curd number 200–275 showed that the accuracy for single measurement was 8.4, duplicate measurement 6.0, and triplicate measurement 4.9. There was no significant trend of variance as the mean increases from 205 to 272. That this calculated variation for homogenized milk is less than that for pasteurized milk indicates that the accuracy of the curd number test is contingent in part upon the type of milk processed.

FAT CONTENT OF THE CURDS

In order to have a clearer understanding of the nature of these artificially produced milk curds their butter fat content was compared with the values for the fluid milk before coagulation. Curds after being thoroughly dried out at room temperature were extracted with ether in a soxhlet apparatus and the percentage of ether soluble substance calculated as butter fat. Table 4 shows the results obtained with raw, pasteurized and homogenized milks. Generally speaking, about 90 per cent of the butter fat was caught in the curds, irrespective of the original form of the milks. Check determinations demonstrated the balance to be contained in the whey. Interestingly, the analyses bring out that with market milks containing about 4 per cent butterfat the curds which form are half protein and half fat, and that when the fat content of the milk is lower or higher the fat content of the curds fluctuates correspondingly. These observations corroborate the find-

TABLE 4

Fat content of curds

Specimen number	Type of milk	Original fat content of the milk (gm. per 100 cc.)	Weight of curd produced by 100 cc. milk	Fat content in curds from 100 cc. milk	Total fat caught in curds	Fat per 100 gm. of air-dried curd	Residue per 100 gm. of air-dried curd
		gm.	*gm.*	*gm.*	%	*gm.*	*gm.*
1	Raw	4.10	7.22	3.72	90.6	51.5	48.5
2	Raw	4.12	7.31	3.68	89.5	50.3	49.7
3	Raw	3.88	7.73	3.50	90.2	45.1	54.0
4	Past.	3.92	6.91	3.41	86.9	49.3	50.7
5	Past.	3.92	6.84	3.61	92.0	52.1	47.9
6	Homog.	4.21	7.32	3.90	92.6	53.3	46.7
7	Homog.	4.22	7.37	3.89	92.5	52.8	47.2
8	Homog.	4.30	7.29	3.91	90.9	53.6	46.4
9	Homog.	4.30	7.15	3.91	90.9	54.7	45.3
10	Homog.	4.30	7.17	3.93	91.4	54.8	45.2
11	Homog.	4.30	7.11	3.93	91.4	54.9	45.1

ings of Freudenberg (5), and coincide with the experience of cheese-making practice. If the curds which form within the human stomach are similar in composition to those produced in vitro—and there is no evidence to suggest they are not—then one would not expect to find milks high in butter fat appreciably retarding the emptying time of the stomach, since the increased fat being trapped in the casein coagula is not free to exert its specific stimulus upon the gastric mucosa.

PRACTICAL APPLICATIONS

The secretion of acid and pepsin by the gastric mucosa following the taking of milk varies from individual to individual and is inconstant even in the same subject on successive determinations, being dependent upon such

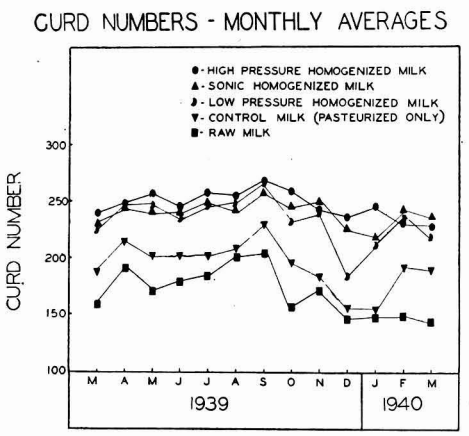

FIG. 6. Average "curd numbers" of milks used in a clinical feeding study. A seasonal swing is present in all the milks, the numbers being lowest in March, climbing to a wavelike crest in September, and receding to another low in the following Spring. The rise in values for pasteurized milk during February and March, 1940, results from the change to a high pasteurizing temperature—160° F. for 30 minutes instead of the 145° F. previously used (from table 5). The curds were prepared for measurement at pH 4.9 with the hand-squeezing technique.

influences as age, state of health and nutrition, emotional balance, innate capacity and presence or absence of fatigue (8, 12). This changeful composition of the gastric juice would be expected to reflect itself in altered patterns of coagulation even when the character of the milk itself is kept constant. With the curd number test each component in the curdling system can be individually altered and its significance evaluated in terms of physiologic values. Such extrinsic factors as the effect of hydrogen ion concentration changes, the alterations in relative content of pepsin or hydrochloric acid or both in the coagulating fluid, the rapidity with which coagulating solution is added, the significance if any of the temperature of the

swallowed milk and the prominence to be attached to the motor activity within the moving system all become subject to analysis by means of this new approach.

For the past two years the curd number test in its present form has been subjected to daily use and scrutiny. It has been found adaptable for the study of differences among raw milks, changes produced by various processes and modifications upon these same milks and the influence of factors present in the stomach upon curd formation. Thus raw milk specimens from diverse sources of supply and at the various seasons have been found to present great differences among themselves as reflected by curd number determinations. Processing and changes made in the milk become similarly reflected (fig. 6). The influence of increments of added acid upon curd size is indicated by progressive elevations in the curd numbers (fig. 5). Breakdown of fat particles by homogenizing results in a striking increase in the curd number values (fig. 5). Similarly in the heating of milk progressive increase of either the temperature or the time factor produces an elevation in the values obtained (figs. 7, 8). A detailed report of the observations gained by the use of the curd number test in the evaluation of current practices of processing cow's milk for marketing purposes and of modifying milk for infant feeding will be published separately (14).

CURD NUMBER AND CURD TENSION

The curd tension test, though limited by its inflexible rigidity to use with undiluted milk only (9), is simpler, quicker and more economical than the curd number test, and gives results more promptly. It is specially suited for work in the dairy plant and testing laboratory, where it can be used for checking on the day-to-day output of milk for soft or hard curd properties. The curd number test on the other hand is more sensitive, broader in scope and offers richer potentialities for research investigations on milk and milk products. The two methods can be considered to complement one another; each may be used to check the other.

A great mass of comparative data bearing on the relationships between these two tests has been accumulated (14). Generally speaking, the results obtained by the two methods run more or less parallel, indicating that the techniques measure similar or closely related properties of milk. For example, the readings for curd number and for curd tension on milks held at constant temperatures for varying periods of time have shown close correlation in their rates of changes (figs.7, 8). Milks from different sources, however, often possess similar curd numbers but differing curd tension values, and vice versa. On several occasions certain manipulations of milk have resulted in marked changes of curd number in the direction of soft curd character without appreciably altering the curd tension values.

CURD NUMBER AND DIGESTIBILITY

The problem of immediate importance is to determine the validity of the "curd number" test as an index of digestibility. Does this arbitrarily established procedure measure some significant property of milk which is responsible for differences in digestibility? Does a low curd number actually

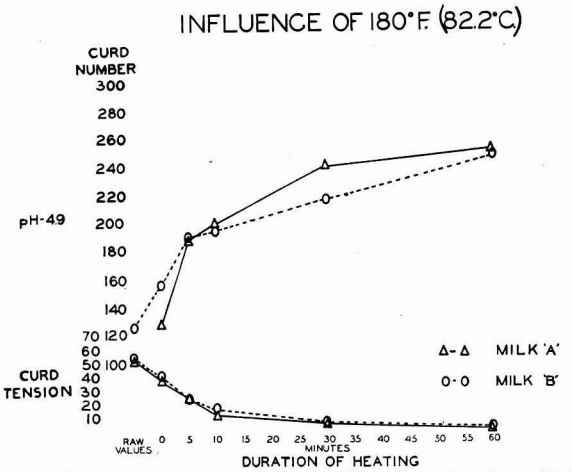

FIG. 7. Comparison between curd number and curd tension for milk heated to 180° F. (82.2° C.) and held for various minutes.

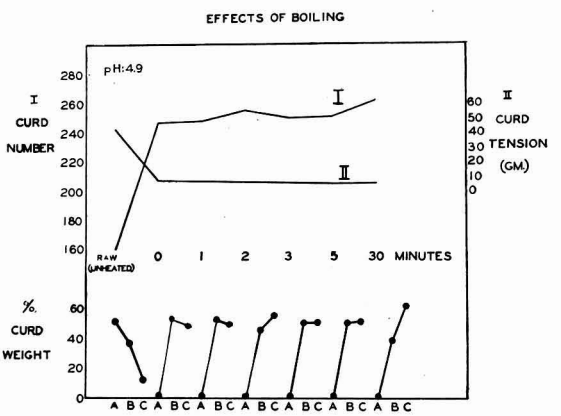

FIG. 8. Curd tension and curd number for milk heated to boiling temperature and held for various minutes—correspondence with a, b, c diagram demonstrated.

correspond to "hard-curd milk," and does milk with a high number prove to be "soft-curd" and more readily digestible? If so, where does the dividing-line or threshold fall?

In order to obtain pertinent information concerning the above questions, determinations of curd number were secured at frequent regular intervals

during the course of a 15-month infant-feeding study (13) in which it was found that milks processed by (a) sonic homogenization, (b) "low pressure" homogenization and (c) "high pressure" homogenization, and used as the basic food for infants, were comparable in ease of digestibility with pasteurized milk boiled for five minutes. More than 200 normal infants were successfully raised on each type of milk without exhibiting symptoms or signs of digestive disturbances attributable to imperfect utilization of the milk within the gastro-intestinal tract. Figure 6 summarizes the "curd number" data for the milks obtained from some 400 tests, as measured at pH 4.9 with the "hand squeezing" technique. The raw milk gave the lowest value; the pasteurized milk fell next in line, whereas the three varieties of homogenized milk, and boiled milk, were grouped together at a higher level. Although a great seasonal swing was reflected in all the milks, no concomitant changes in the infant's feeding behavior became manifest. Save for an occasional transient exception, the majority of homogenized milk specimens from the experimental study gave curd numbers which when adjusted by calculation to the circumstances of coagulation at pH 5.5 with mixing by shaking (test conditions which seem most satisfactory) fell at or usually above 200. That these three varieties of homogenized milk processed by three different and distinct techniques were equally and efficiently metabolized by such a large group of healthy normal infants seems evidence enough to characterize them all as soft curd milks as this designation is applied (3, 4). One may generalize further and point out that other homogenized milks having curd numbers at or above 200 would presumably be tolerated with comparable ease of digestibility, provided of course that their sanitary and other features were not unsatisfactory. Whether other forms of milk not homogenized can be subjected to the same criterion remains to be determined, as is also the problem of evaluating the digestibility of less thoroughly processed homogenized milks which yield curd numbers below this observed limiting value.

SUMMARY AND CONCLUSIONS

When a specimen of milk is made to coagulate within an artificial curdling device under rigidly controlled conditions, the curds which form manifest a size distribution which appears to be a constant physical characteristic of the milk undergoing test. After hardening, drying, sieving and weighing the masses of curds thus obtained and then applying to the weight data a so-called "a-b-c" formula empirically derived, it is possible to arrive at a "curd number" which epitomizes the milk's curdling qualities. This proposed technique for curd number has been subjected to critical analysis and found to be experimentally useful in problems dealing with the coagulating properties of cow's milk preparations as related to human digestion. Curd

number has been found in general to run parallel to curd tension, though broader in scope and with greater applicability to research.

ACKNOWLEDGMENT

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CURD STRENGTH OF EVAPORATED MILK*

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In the milk and cheese industry the subject of curd strength as expressed in grams is commonplace. Limited information, however, relating to this subject is available for evaporated milk. A study was undertaken to obtain information of this and closely allied subjects.

PROCEDURE AND RESULTS

A desired range of samples was procured through the cooperation of the Evaporated Milk Association. Single plant samples from 19 states, samples from two plants in Ohio and also Pennsylvania and from 3 plants in Wisconsin were obtained. These samples were from batches made between June 10 and 15, 1940. Composition, sterilization data and place of manufacture appear in table 1. These values supplied by the Association were studied statistically before our studies were undertaken.

To obtain curd tension values both concentrated and diluted samples were used. Curdling periods were extended whenever the Hill, Miller or Geneva (2, 3, 1) procedures gave negative results. A range of acid percentage was also studied for the Miller procedure.

The creaming capability of re-constituted samples was also studied. Fat percentages in various layers of 1000 ml. amounts were used to study the creaming properties. All samples were set at 4.5° C. (40° F.) for 18 hours. In one series the fat percentages were determined in the upper 100 and lower 900 ml. In the other gravitations the fat percentage was multiplied by 4.1, the normal mean percentage factor for creaming power of raw milk, and this percentage value divided by two gave the amounts of the 1000 ml. to be taken for the upper and center layers. The remainder was used as the lower layer. All samples were observed for flavor, body and color.

A review of the analyses reveals that the mean fat percentage of the 26 samples is 7.94. Twenty-three samples fall within the fat error tolerance of the mean value, the other three samples within 0.1 per cent deviation from the mean. This degree of uniformity of composition has been achieved by a system of technical control, inspection and checking by the industry which has significance in this study since it enabled the supplying of 26 comparable samples as far as fat content is concerned.

The degree of uniformity of the total solids is quite comparable to that of the fat content. The mean value for total solids percentage is 26.23.

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The median, 26.15, deviates less than 0.1 per cent from the mean value. The mean value within the inter-quartile range, 26.19, falls mid-way between the median and mean values. More significant, however, is the fact that with one exception all total solid values vary less than 0.5 per cent. This means that the samples are quite comparable for total solids percentages. This is on the premise that total solids are more difficult to control than fat

TABLE 1

Composition, sterilization data, place and date of manufacture of the evaporated milk samples used

Sample	Date of mfgr.	State	Milk fat	Total solids	Sterilization	
					Time	Temp.
			Per cent	*Per cent*	*Min.*	*°F.*
1	6/10/41	Pennsylvania	7.93	26.13	16	244
2	6/12/41	New York	7.92	26.18	16	242
3	6/11/41	Oregon	7.93	26.11	15	243
4	6/10/41	Ohio	7.96	26.08	14	242
5	6/10/41	Virginia	7.93	26.30	15	243
6	6/14/41	Washington	7.95	26.02	15	243
7	6/12/41	Wisconsin	7.93	26.06	15	243
8	6/12/41	Texas	8.01	26.05	14	242
9	6/11/41	Iowa	7.93	26.37	15	242
10	6/13/41	Minnesota	7.94	26.05	15	242
11	6/10/41	Colorado	7.93	26.05	14	242
12	6/14/41	Pennsylvania	7.95	26.11	15	246
13	6/14/41	Illinois	7.93	26.15	15	242
14	6/15/41	California	7.85	26.01	14.5	244.5
15	6/11/41	Ohio	7.94	26.95	13.5	245.5
16	6/13/41	Alabama	7.96	26.25	15	242
17	6/10/41	Kentucky	7.95	26.31	15	244.5
18	6/11/41	Mississippi	7.94	26.42	14	242
19	6/10/41	Maryland	7.95	26.43	15	242
20	6/11/41	Tennessee	7.97	26.28	15	245
21	6/15/41	Michigan	7.94	26.16	15	245.5
22	6/15/41	Wisconsin	7.94	26.30	15	241.5
23	6/12/41	Idaho	7.94	26.40	11	244
24	6/12/41	Utah	7.95	26.51	13.5	243
25	6/11/41	Wisconsin	7.95	26.26	15	243.5
26	6/11/41	Indiana	7.95	26.07	15	240

percentages. Therefore these samples represent the maximum in likeness achievable in total solids control.

The values in table 2 give the curd strength of the complete series by the Hill, Miller and Geneva methods as described by Dahlberg *et al.* (1). This investigation was in progress when the American Dairy Science Association Procedure for Measuring Curd Strength was published. Present investigations are being conducted with the approved procedure of the Association adopted in September, 1941. The diluted samples were equal parts by weight of evaporated milk and water. The values reveal that all the undiluted samples fall within the soft curd milk range as defined by Hill (2). Over two-thirds of the undiluted samples meet the requirements in Hill

units as set forth by the American Medical Association for normal homogenized milk. All undiluted sample curd strengths meet the American Medical Association Standards when expressed in Miller Units (3).

TABLE 2

A presentation of the curd strength of evaporated milk

Sample	Undiluted			Diluted*		
	Hill	Miller	Geneva	Hill	Miller	Geneva
1	20	10	0	4	2	0
2	19	10	0	4	2	0
3	20	12	0	4	2	0
4	21	10	0	5	2	0
5	30	12	0	4	0	0
6	30	12	0	6	0	0
7	22	8	0	3	0	0
8	30	12	0	6	2	0
9	20	8	0	4	2	0
10	20	10	0	4	4	0
11	16	12	0	4	3	0
12	16	12	0	4	4	0
13	12	12	0	4	3	0
14	30	10	0	4	4	0
15	26	10	0	4	6	0
16	22	12	0	4	2	0
17	22	14	0	4	4	0
18	18	12	0	4	4	0
19	22	0	0	4	0	0
20	22	0	0	4	0	0
21	16	0	0	4	0	0
22	16	0	0	4	0	0
23	18	0	0	6	0	0
24	20	0	0	3	0	0
25	26	0	0	4	...	0
26	24	0	0	5	...	0

* Diluted for this series refers to equal parts by weight of evaporated milk and water.

The diluted values present samples with a very low curd tension, 6 or below expressed in Hill or Miller units. Homogenized milk as sold seldom has a curd value as low; most samples having values within a 12 to 20 range. This is well established and verified by unpublished data in our files. The fact that curd values were not attainable due to lack of setting with the Geneva procedure stimulated further investigations with this procedure.

The flavor, body, and color comments are not included in table 2 as all samples rate a "good" on flavor and body. Eighteen samples were comparable in color with 4 being slightly lighter and 4 slightly darker than the 18. These variations were not significant.

Four samples which failed to set curds in 10 minutes with the Miller and Geneva solutions were tested after 30 and 60 minute intervals, and failed to give curds within these periods. Both solutions set curds with the four selected samples after 24 hours. The Miller values were 15, 12, 5 and 4;

whereas under the same condition the Geneva values were 12, 12, 12 and 6. In the above trials a 0.4 per cent HCl solution was used for the Miller solution. Increasing this concentration 0.1 or 0.2 per cent gave quite normal results with the samples which failed to set with the standard Miller solution. Likewise samples which set normally with a 0.4 per cent HCl Miller solution failed to set when the concentration was decreased 0.1 or 0.2 per cent. Slight variations in reaction may give decided difference in values when measurements are made after 10 minutes.

To answer the question concerning the changing of curd strength of evaporated milk after being held at room temperature for 6 months, the curd tension on all samples was repeated during December. The values obtained are not presented as the results showed no change in curd strength as measured by the Hill, Miller or Geneva procedures as outlined in this study which could be attributed to aging for 6 months at room temperature.

The creaming tendency of re-constituted evaporated milk is important. Extensive creaming studies were made with 7 samples. In the first series the re-constituted evaporated milk was creamed in 1000 ml. cylinders for 18 hours at 4.5° C. (40° F.). The upper 100 and lower 900 ml. were analyzed. In the second series the fat percentage multiplied by 4.1 and divided by 2 as previously described gave the amounts of upper and center portions, the remainder being regarded as the lower layer.

TABLE 3

Creaming tendencies of re-constituted evaporated milk as measured by two procedures

Sample	Per cent fat dil.	Procedure 1*		Procedure 2†		
		Per cent fat 100 ml. upper	Per cent fat 900 ml. lower	Upper	Center	Lower
1	3.7	3.7	3.7	3.8	3.7	3.7
2	4.0	4.0	4.0	4.0	4.0	4.0
3	3.7	3.7	3.6	3.7	3.7	3.6
4	3.9	3.9	3.9	3.9	3.9	3.7
5	3.7	3.7	3.6	3.8	3.7	3.7
6	3.8	3.8	3.8	3.8	3.8	3.8
7	3.9	3.9	3.7	3.9	3.8	3.7

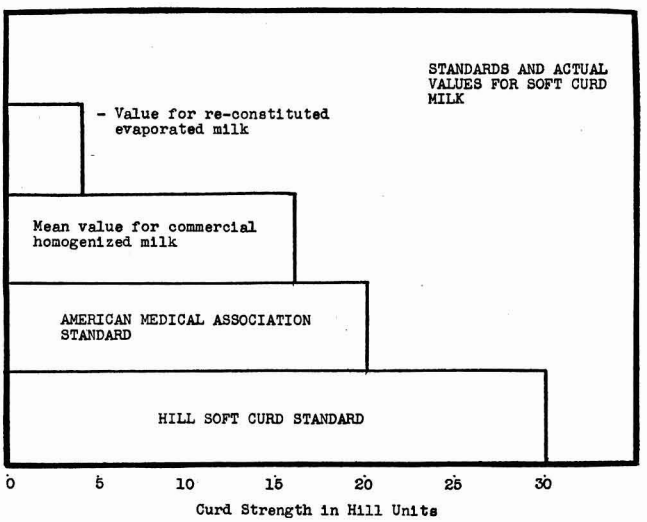
* These layers were obtained by removing 100 ml. from a quart of milk held at 40° F. for 18 hours.

† These layers were obtained from 1000 ml. of milk set at 40° F. for 18 hours. The upper and center layers were obtained by multiplying the fat percentage by 4.1, the creaming factor for normal milk, and dividing the result equally for the two layers. The remainder was taken as the lower layer.

The creaming tendencies are summarized in table 3. It is apparent that as far as practice is concerned the evaporated milk samples have their creaming tendency eliminated. The variations in fat percentages in table 3 are greater than those recorded in table 1. The values in table 3 were obtained with a modified Babcock procedure whereas those in table 1 were

ether extract analyses. A variation in fat content of not more than 0.2 per cent was found between the various layers when compared to the re-constituted control.

Further experimentation with 6 samples revealed that dilution as great as 5 per cent of milk and 95 per cent of water failed to induce creaming properties. The samples were selected at random; the percentages of evaporated milk used were 5, 25, 50, 75, and 95. After creaming at 4.5° C. (40° F.) for 18 hours lower and upper layer means checked within 0.2 of the fat percentage of the mixed samples by the Babcock procedure. For example, all samples when mixed with equal amounts of water by weight gave a mixture containing 4.0 per cent of fat. The upper layer had a mean value of 4.0 per cent; which was also the percentage present in the lower layer; cor-



Curd strength of re-constituted evaporated and homogenized milk compared to the American Medical Association and Hill Standards.

responding values for the 75 per cent evaporated milk and 25 per cent water mixtures were within 0.1 of a value of 6 per cent. The mixture with 25 per cent of evaporated milk gave values within the 0.1 range of 2.0 per cent. The 5 per cent mixtures contained 0.5 per cent fat and the lower and upper layers checked within 0.2 per cent of this value. The mean values for the mixture, upper and lower layers for the 95 per cent evaporated milk mixture were 7.4, 7.5, and 7.4. These results established that dilution percentage is not a factor in the non-creaming of diluted evaporated milk.

CONCLUSIONS

The curd strength of re-constituted evaporated milk is far less than that of commercial homogenized milk. Its curd strength is well within the standard set by the American Medical Association of 20, measured in Hill units.

Re-constituted evaporated milk, when mixed with equal volumes of water by weight, will not lose its homogeneous properties when held at 4.5° C. for 18 hours.

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VITAMIN A AND CAROTENE REQUIREMENTS FOR THE MAINTENANCE OF ADEQUATE BLOOD PLASMA VITAMIN A IN THE DAIRY CALF[1]

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A number of studies have been reported on the carotene requirement of dairy cattle without complete agreement. The carotene requirements as determined by Guilbert and coworkers (7, 8) have been supported by Ward *et al.* (19), Moore (17), and Halverson *et al.* (9). Reproduction apparently increases the requirement (4, 6, 7). However, from studies reported by Meigs and Converse (16) and Phillips *et al.* (18) it appears that the growing calf requires more carotene than the minimum requirement proposed by Guilbert *et al.* (7, 8).

In a recent study of the relationship of avitaminosis A to ascorbic acid in the young bovine (3) it was found that the blood plasma ascorbic acid was contingent upon the blood level of vitamin A, in particular when plasma vitamin A values fell below 10γ per 100 cc. If blood plasma levels of 5–7γ per 100 cc. or less continued, vitamin A deficiency symptoms and pathology appeared. These data suggested that the blood plasma vitamin A was an index of the status of the vitamin A nutrition of the calf. On the basis of these preliminary results it seemed possible that the minimum requirements of carotene and vitamin A could be determined by using the blood plasma vitamin A as a critical measure of vitamin A nutrition. The results of such an experiment are herewith reported.

EXPERIMENTAL

The data given in this paper were secured from 6 calves (3 Guernseys, 2 Holsteins, and a Holstein-Brown Swiss) placed on experiment when they were approximately 4 weeks of age. They were divided into three lots of one Holstein and one Guernsey each so that three ingestion levels of vitamin A or carotene could be simultaneously compared. The calves were fed the low carotene ration of Walker (18) which was composed of white corn 22 parts, linseed oil meal 23 parts, wheat middlings 11.5 parts, oat mill feed 40 parts, ground limestone 3 parts, iodized salt 0.5 parts and irradiated yeast 0.1 part. The ration averaged about 5–8γ carotene per pound. Skimmed milk supplements were fed during the early weeks of the experiment.

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Blood plasma carotene and vitamin A determinations were made at weekly intervals throughout the experiment by an adaptation of Kimble's method (14). Results of the vitamin A analyses were expressed in terms of micrograms on the basis of measurements with pure vitamin A.[2] Occasional ophthalmoscopic examinations were made for the purpose of correlating with the blood analyses. Body weights were taken at weekly intervals and all animals were closely watched for gross symptoms of vitamin A deficiency.

Supplements of crystalline carotene in cottonseed oil, shark liver oil, and alfalfa were fed as source materials for vitamin A or carotene. The solution of carotene in cottonseed oil was prepared by dissolving one-half gram of carotene in a few cc. of chloroform and adding this to 600 cc. of cottonseed oil previously heated in an oven to 70–80° C. The resulting solution was cooled immediately under running tap water and stored in the refrigerator until used. Each solution was analyzed for its exact carotene content before use. The shark liver oil was an excellent quality, high potency, straw-colored oil.[3] The potency of the oil was checked by means of the antimony trichloride reaction (5).[2] The alfalfa hay was Nebraska-grown hay of good quality and color. The carotene content of the hay was determined by the method of Hegsted *et al.* (11).

It was planned to determine the blood plasma vitamin A levels which would be adequate, borderline, and inadequate for the calf, and the required ingestion of vitamin A necessary to support these blood levels. Further, it was planned to determine what were the carotene requirements for the maintenance of an adequate blood plasma vitamin A.

After the calves were placed on experiment it required 30 days to deplete their stores and to reduce the blood plasma vitamin A to a low level, and thus properly condition them for the determination of necessary vitamin A intakes and plasma levels. During the next 90 days an attempt was made to stabilize the blood plasma vitamin A levels at 10–12γ per 100 cc., 8γ per 100 cc. and 4γ per 100 cc. in groups I, II, and III, respectively. These were levels which previous results indicated would be adequate, borderline, and inadequate for vitamin A nutrition. On the basis of the results obtained vitamin A was fed at constant levels for the next 90 days. The ingestion was based upon body weight corrected weekly. Following this period, supplements were withdrawn to ascertain if any storage of A had occurred and to properly stabilize the calves for determining the carotene requirements. The depletion time required for this was 35 days. Three levels of carotene (20, 40 and 60γ per kg. of body weight per day) were then fed for 75 days. Since it became apparent that these levels were inadequate, the carotene in-

[2] The results of the vitamin A analyses may be subject to slight modification as the shark liver oil or the blood plasma might possibly contain chromogens other than vitamin A with respect to the antimony trichloride reaction.

[3] Generously supplied for these experiments by Bioproducts Inc., Astoria, Oregon.

TABLE 1

The relation of blood plasma vitamin A to carotene and vitamin ingestion and to growth

Period of exp.	Lot I Supplement (γ/kg. of body wt.)	Calf 1 (Holstein) Ave. daily gain	Blood plasma Vitamin A	Blood plasma Carotene	Symptoms	Calf 2 (Guernsey) Ave. daily gain	Blood plasma Vitamin A	Blood plasma Carotene	Symptoms
days		*lbs.*	*γ/100 cc.*	*γ/100 cc.*		*lbs.*	*γ/100 cc.*	*γ/100 cc.*	
30–120	Vitamin A— 13*	1.42	10	8	None	1.22	11	16	None
120–210	" "— 18	1.37	11	12	"	1.11	12	22	"
210–245	None	0.97	4	8	"	0.31	3	27	+ (papil-ledema)
245–320	Carotene — 60	0.15	7	40	+	0.09	4	71	++
335–370	" (H) 75 " (G) 125	0.93	10	64	None	1.10	9	135	None
	Lot II	Calf 3 (Holstein)				Calf 4 (Guernsey)			
30–120	Vitamin A— 8–10*	1.41	8	6	None	0.70	7	11	±
120–210	" "—(H) 12 " " (G) 17	1.30	8	13	"	0.82	8	18	+ (papil-ledema)
210–245	None	0.89	3	9	+ (papil-ledema)	−0.50	3	17	+++
245–320	Carotene—40	0.58	5	28	+		Died of vitamin A deficiency		
335–370	" —75	0.82	8	51	None				
	Lot III	Calf 5 (Holstein-Brown Swiss)				Calf 6 (Guernsey)			
30–120	Vitamin A— 3*	0.95	7	14	Emaciated	0.70	4	9	Emaciated
120–210	" "—6–7	0.78	6	14	+	0.93	5	15	+++ (papil-ledema)
210–245	None	0.94	3	15	++ (papil-ledema)	0.60	3	14	+++
245–320	Carotene —20	0.52	4	22	+++	0.31	4	28	++++
335–370	" (H.–B.S.) 100 " (G.) 125	1.31	9	75	Recovered	1.17	10	139	Recovered

* In the period 30–120 days the intakes were experimentally varied and thus the blood levels fluctuated. The figures given are averages and are somewhat higher than the results obtained later on constant intakes. The figures for the remaining periods represent the values obtained on the respective intakes after the blood levels became relatively constant.

take for all calves was increased to 100γ per kg. of body weight for 15 days after which the intakes were modified as needed and fed for another 35 days. Thus the experiment extended over a 370-day period.

RESULTS

The data in table 1 show the effect of blood plasma vitamin A on growth. When the blood plasma vitamin A values were 10γ or above per 100 cc. the calves gained a pound or more of weight per day. Lower concentrations of blood plasma vitamin A were accompanied by a decreased rate of growth and practically complete inhibition of growth followed when blood plasma vitamin A fell to levels of 4γ per 100 cc. or less. A noticeable lag was evident between the blood plasma vitamin A and the growth response. When the blood plasma vitamin A was sharply reduced decreased growth did not result for as long as 30 days afterward, thus indicating that the blood plasma vitamin A provided a much more sensitive criterion of the status of vitamin A nutrition than growth. The growth rate was good on intakes of 18γ of vitamin A per kg. of body weight per day, but was markedly inhibited on the low intakes of 6γ per kg. of body weight.

As shown in table 1, plasma vitamin A levels of 10–12γ per 100 cc. prevented the appearance of any deficiency symptoms over a 6 month period (Calves 1 and 2). Levels of 7–8γ per 100 cc. were borderline in the prevention of the development of vitamin A deficiency symptoms (Calves 3 and 4). If blood plasma vitamin A levels of 4–6γ per 100 cc. or less were allowed to persist, deficiency symptoms invariably developed (Calves 5 and 6).

The vitamin A intakes necessary to maintain the different levels of blood plasma vitamin A were consistent for all calves except number 4. In general, the ingestion of 18, 12, and 6γ of vitamin A per kg. of body weight per day resulted in adequate, borderline and inadequate blood plasma concentrations of vitamin A.

With these values established the vitamin A supplements were withdrawn on the 210th day for a period of 35 days. The rapid fall in plasma vitamin A and the appearance of symptoms indicated that even on the highest level of ingestion storage of vitamin A was not great. At the end of this period a small amount of vitamin A was given calves 5 and 6 to raise their blood plasma vitamin A to a par with the other calves. All calves were then placed on carotene supplements as the source of vitamin A. The calves in lots I and II were given the carotene solution and those in lot III were given alfalfa hay as a source of carotene. Carotene was first fed at intakes of 60, 40 and 20γ per kg. per day. The 20 and 40γ levels were totally inadequate and even the 60γ level was definitely subminimal for maintenance of adequate blood plasma vitamin A and the prevention of deficiency symptoms. During this period the blood plasma carotene content increased to double the minimum carotene level suggested by Moore (17). These results are in

accord with earlier unpublished data obtained by us in which it was found that vitamin A deficiency in calves developed on carotene intakes of 50–60γ per kg. per day.

On the 320th day the carotene ingestion level was increased to 100γ per kg. for all calves. Within a short time it became evident that this level was more than adequate for the Holsteins and inadequate for the Guernseys, indicating that there was a breed difference in the carotene requirements. The carotene intakes were then adjusted to 75γ per kg. of body weight for the Holsteins and 125γ for the Guernseys, and the Holstein-Brown Swiss maintained at 100γ per kg. These intakes of carotene resulted in blood plasma vitamin A values of 8–10γ per 100 cc. over a 35-day period. The results of these experiments indicated that no difference existed in the availability of the carotene in cottonseed oil and the carotene as present in alfalfa. Whether the ingestion of an equivalent carotene level from alfalfa would in time prove superior to crystalline carotene dissolved in oil was not answered by this study.

The data covering the relation of carotene and vitamin A are summarized in table 2. It is seen that an intake of 18γ of vitamin A per kg. of body

TABLE 2

Summary data on the relationship of carotene and vitamin A intake to the blood level of carotene and vitamin A

Daily intake		Blood plasma vitamin A		Blood plasma carotene	
Carotene	Vitamin A	Holstein	Guernsey	Holstein	Guernsey
γ/kg.	*γ/kg.*	*γ/100 cc.*	*γ/100 cc.*	*γ/100 cc.*	*γ/100 cc.*
No supplementation					
5– 10*	0	3	3	11	19
Vitamin A supplementation					
5– 10*	6	6	5	14	15
5– 10	12	8	.....	13	.....
5– 10	18	12	12	11	22
Carotene supplementation					
25– 35	0	.....	4	.....	28
35– 45	0	5	.....	8	.....
45– 55	0	5	.....	12	.....
55– 65	0	6	4	16	71
65– 75	0	7	.....	32	.....
75– 85	0	9	.....	58	.....
95–105	0	.....	7	.....	105
125–135	0	.....	10	.....	137

* Supplied by basal ration.

weight was required to maintain a blood plasma level of 10–12γ per 100 cc. for both Guernseys and Holsteins. This requirement is an addition to the residual carotene supplied by the basal ration. The response to graded

doses of carotene showed that intakes of 75–85γ per kg. of body weight per day were necessary to bring the blood vitamin A to 10γ per 100 cc. in the Holstein. To reach the same level in the Guernsey 125–135γ per kg. was needed. Thus on the basis of blood analyses vitamin A was found to be 5 to 8 times as efficient as carotene in maintaining an adequate blood plasma vitamin A. These values are in good agreement with the ratios proposed by Guilbert *et al.* (7, 8).

When carotene was fed as the sole source of vitamin A, the Holsteins required 50–70γ of carotene per 100 cc. of blood plasma for the maintenance of a vitamin A level of 10γ per 100 cc. The requirements for the Guernsey were definitely higher. They required from 110–140γ of carotene per 100 cc. to maintain an adequate plasma vitamin A level.

DISCUSSION

The carotene and vitamin A requirements found in these experiments are not without support from other investigations. Meigs and Converse (16) found that for young calves vitamin A intakes up to approximately 22γ per kg. and carotene intakes up to approximately 87γ per kg. of body weight per day were inadequate. They interpret their data as indicating a higher need for the first 3–4 months of life. Our experiments extended over more than a year. Booher *et al.* (2), Jeghers (13) and others have found that the human adult requires somewhat higher absolute levels of vitamin A or carotene than the minimum requirements postulated by Guilbert *et al.*

The minimum values indicated by our work are about equal to those shown to be necessary for normal reproduction and optimal dark adaptation by Guilbert *et al.* (7, 8), but they are 2–3 times as great as their minimum intakes. It may be that intakes which prevent nyctalopia under conditions of their experiments do not represent true physiological minima. In this regard Moore (17) showed that on a carotene intake of approximately 35γ per kg. nyctalopia may be prevented and the outward appearance may be normal, but it may not be sufficient to keep the cerebrospinal pressure normal as indicated by papillary changes. In Moore's experiments (17) papillary edema appeared before nyctalopia in several calves, and carotene intakes of 35γ per kg. did not cure papilledema over a year's period in some calves.

In studies on human nutrition several investigators (10, 12, 15) have shown that poor dark adaptation may occur before vitamin A deficiency becomes so extreme as to result in clinically manifest symptoms such as night blindness and xerophthalmia. Bodansky *et al.* (1) have concluded that the plasma vitamin A is a considerably more sensitive indicator of vitamin A deficiency than is dark adaptation. They found that in infants with a low concentration of blood plasma vitamin A normal dark adaptation could be restored without increasing the level of plasma vitamin A.

Guilbert and coworkers (7) have demonstrated normal or nearly normal

growth over extended periods on their minimum carotene intakes. In our studies we have found that gains in weight may be expected for some time after sub-minimal plasma vitamin A values have been reached, and that some weight gain may continue for long periods on carotene intakes low enough to allow a marked deficiency to develop.

Moore (17) has reported that when plasma carotene values fall to 13γ per 100 cc. or lower in Holstein calves a vitamin A deficiency is likely to develop. In our experiments the carotene values have often decreased to this level before outward deficiency symptoms appeared. However, it was necessary to maintain the plasma carotene values considerably above 13γ per 100 cc. in order to maintain an adequate blood plasma vitamin A. Some individual variation was apparent in the amount of plasma carotene necessary to maintain an adequate plasma vitamin A content. The range for Holsteins was 50–70γ of carotene per 100 cc. and for Guernseys 110–140γ of carotene per 100 cc. These data were obtained when the calves had been on experiment for about one year. They were at the time somewhat undersized but otherwise good experimental animals.

SUMMARY

Studies have been made to determine the blood plasma concentrations and the intakes of carotene and vitamin A necessary for the growing calf.

The data obtained showed that the blood plasma vitamin A was a more delicate measure of the state of vitamin A nutrition in the calf than either growth or blood carotene. A blood plasma vitamin A level of 10γ or more per 100 cc. was found to be necessary for adequate vitamin A nutrition of the growing calf. Blood plasma vitamin A levels of 7–8γ per 100 cc. were borderline levels while values below this were definitely inadequate.

Daily intakes of vitamin A which would maintain deficient, borderline, and adequate concentrations of blood plasma vitamin A were found to be approximately 6, 12 and 18γ per kg. of body weight respectively. The daily carotene requirements necessary to maintain an adequate plasma vitamin A and prevent deficiency symptoms were 75γ per kg. for Holstein yearlings and 125γ per kg. for Guernsey yearlings.

The blood plasma carotene levels which would maintain an adequate blood vitamin A were 50–70γ of carotene per 100 cc. for Holsteins and 110–140γ of carotene per 100 cc. for Guernseys.

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MINERALS IN DAIRY CATTLE NUTRITION: A REVIEW

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Different nutrients during past decades have held the spotlight, more particularly the proteins, minerals, and vitamins. Vitamins during the past twenty years have been stealing the scene from the minerals. Nevertheless, due in part to the promotion of mineral feeds, there is a concern in the minds of dairymen about possible mineral deficiencies among their cattle. Possibly the more or less constant need for salt and the chore of feeding salt have served as reminders that minerals other than salt may be necessary.

Since common methods of cropping and of pasturing land without compensatory returns tend to deplete the land and its products of certain minerals, it is not illogical to reason that this deficiency might be reflected in the well-being of animals subsisting on such pastures or hay crops. The animals might react all the more certainly if, meanwhile, as a result of a more or less consistent breeding program, they had been endowed with a strong growth impulse or milk-producing ability, and therefore might be making keener demands upon their rations. Nor would it seem that this picture is improved any by periodic occurrences of drought (8) making for poor phosphorus assimilation on the part of the growing vegetation. There may also be added the factor of unfavorable haying seasons, the shattering of leaves in the field, and the resulting coarse, perhaps discolored, musty hay. In view of these factors or possibilities, the concern of this owner or herdsman may, indeed, seem justified.

However, all things are relative. Whether there is a point to becoming alarmed over any serious situation facing the vast majority of dairymen may be seen from a survey of experimental findings.

Fortunately a number of long-continued critical mineral feeding experiments with dairy cows have been concluded during the past fifteen years. For the most part these experiments have focused on the elements calcium and phosphorus that make up by far the larger portion of the mineral composition of cows and of milk. Earlier feeding experiments related to salt and iodine, a few to sulphur. But more recent experiments, many of them growing out of observations in the field, have had to do with the trace mineral elements and with iron in combination with copper.

Very helpful in a study and appreciation of the mineral problem in dairy cattle and other livestock have been, among others, a number of relatively recent reports of original work, monographs, or bibliographies, by E. B. Forbes and co-workers (20), H. H. Mitchell and F. J. McClure (43), H. Schmidt (55), E. J. Underwood (59), and Muriel E. Whalley (64).

Underlying a consideration of mineral needs by ruminants especially is the status of the mineral composition of pastures and forage crops, on which subject J. B. Orr (47), and more recently Kenneth C. Beeson (8), have made noteworthy contributions. The comprehensive character of the work of these and others obviates the necessity for listing any considerable number of citations in the present limited space assigned to a consideration of minerals in dairy cattle nutrition.

The requirements for the several minerals by cattle usually are expressed in terms of percentage composition of their rations. Naturally the pounds of feed intake determine the pounds or ounces of mineral intake, and this quantitative concept usually is expressed as a specific daily mineral intake for a given live weight. But whether expressed in either one of those two terms, there is surprisingly little reference in the literature (37) to the considerable difference in digestibility or availability of calcium, phosphorus, etc., from perhaps milk, on the one hand, and alfalfa hay on the other, both feeds in varying proportions being fed in mineral feeding experiments with calves. Likewise grain and roughage may in varying proportions be fed in mineral feeding experiments with cows. Obviously, the calcium, phosphorus, or other mineral from milk or grain is more easily digested than are the corresponding minerals from the fibrous tissues of roughage. An assumption that minerals in feeds are digested in keeping with the digestibility of their dry matter would put a unit of minerals from roughages and a unit of minerals from concentrates more nearly on par.

Such variation in digestibility and in availability after having been digested, along with our limited understanding of the true requirements for minerals under various conditions, prompts a liberal margin of safety in the specifications for the several mineral elements in dairy cattle rations.

CALCIUM

Calcium is the major mineral element in respect to quantity contained in the bodies and in the milk of cows. For that reason and because the consequences of calcium deficiencies have been frequently observed, this element has challenged the attention of research workers for many years.

Reed and Huffman (50) in a 5-year experiment with different proportions of calcium in dairy rations made up of timothy hay, corn silage, and a grain mixture with no mineral supplement except salt, found this ration having 0.28 per cent calcium on the air-dry basis, adequate for normal growth, good reproduction, and a liberal milk flow.

Hart, Hadley, and Humphrey (26) in an experiment lasting 5 years and involving 22 cattle in each of two lots, found that only about 0.20 per cent calcium in the ration on the dry basis between pasture seasons permitted good health and, so far as the calcium question was uncomplicated by infection, permitted successful reproduction. The basal ration was

timothy hay, corn silage, and a grain mixture which was made up of corn, oats, corn gluten meal, and salt. The cows in the second group were fed alfalfa hay with corn silage and a grain mixture which consisted of corn, oats, wheat bran, linseed meal, bone meal, and iodized salt. In spite of having several times as much calcium as the first ration, the results were practically the same.

Fitch and co-workers (19) were able to reduce the calcium to 0.18 per cent of the entire ration on the dry matter basis while still obtaining good results in respect to reproduction, calcium content of the blood plasma, and milk and fat production. They state that the animals adjusted themselves to the calcium content of the ration and conserved the quantity ingested when it was limited. The basal ration was made up of timothy hay from acid soil, one per cent cod-liver oil in the grain mixture, and one pint daily of canned tomatoes. Several vitamins, including vitamin D, were therefore provided in relative abundance. Just how much of a saving feature these additions were, may be suggested by the work of Hart and associates (28) showing that the amount of calcium and phosphorus lost from the body of lactating cows was less when green grass was fed than when dry grass was given, and that it was also less when alfalfa hay properly cured in the sunlight was fed than when poorly cured alfalfa hay was fed (31).

To put this question of vitamins and availability of minerals to a further test, Palmer and co-workers (48) withheld the vitamin supplements and further reduced the calcium content of the ration to 0.12 per cent on the dry matter basis. They reported no abortions attributable to this low level of calcium during one or two succeeding gestations. Nor did this ration appear to have any effect upon the milk and butterfat production or the chemical composition or clotting of the milk. It did, however, slightly reduce the total and unfilterable calcium content of the blood plasma and it did lower the ash content of the bones.

The calcium content of milk seems to be independent of the calcium level of the ration (37). Milk secretion draws on the calcium reserves of the body and apparently ceases when the available material for it gives out.

For growth, more particularly for growth and fattening (62) where body reserves cannot be drawn upon as in the case of the cow, added calcium has been shown necessary with rations similarly constituted except for the relatively large proportion of corn or concentrate. With growing cattle also, sunlight or vitamin D which is supplied at times by sun-cured hay, plays a more important role than with mature animals (51). Early consumption of good quality sun-cured hay has been found (39) to obviate the necessity for vitamin A and D concentrate, or cod-liver oil additions.

The Minnesota work with the very low level of 0.12 per cent calcium in the ration of mature cows reveals a surprising adaptability by the animals to a calcium deficiency in the ration. While this low level brought on mildly

unfavorable responses, this experiment nevertheless is reassuring that the margin of safety in commonly used rations may be adequate. A level of 0.18 per cent calcium in experimental rations used by the same station gave good results in the several criteria used.

What does this mean in reference to the Kellner standard of calcium and phosphorus for maintenance and milk production? Kellner (37)

TABLE 1

Testing practical American dairy rations against European mineral feeding standards

	Kellner standard (7, 37)		Wellmann standard (7, 63)	
	Calcium (Ca)	Phosphorus (P)	Calcium (Ca)	Phosphorus (P)
	pounds	*pounds*	*pounds*	*pounds*
1000#-cow, maintenance	.0715	.0218	.0358–.0716	.0131–.0218
1-pound gain in body weight	.....	.....	.0250	.0122
1 pound milk produced	.0018	.0011	.0036	.0020
Standards for milking cow:				
1000#-cow giving 30 lb. milk	**.1255**	**.0548**	**.1438–.1796**	**.0730–.0818**
Ration* for above cow, using timothy hay, corn silage, grain	.0608	.0980	.0608	.0980
.16 lb. $CaCO_3$ with 10 lb. grain	.0647	.....	.....	.....
	.1255			
.21 lb. $CaCO_3$ with 10 lb. grain	.....	.....	.0830	.....
			.1438	
Therefore 1.6% or 2.1% $CaCO_3$ in grain mixture are needed to supply Ca.				
Ration† for above cow, using alfalfa hay, corn silage, grain	.1691	.0835	.1691	.0835
This practical ration is sufficiently rich in Ca and P to satisfy both standards.				
Above ration with bran omitted and correspondingly more oats	.1686	.0690	.1686	.0690
0.112 lb. bone meal with 10 lb. grain	.....	.....	.....	.0145
				.0835
Without bran this ration needs 1.12% bone meal in the grain mixture to supply the same amount of P, but needs only 0.31% bone meal to meet the minimum P of standard				
Standard for growing cattle:				
500#-heifer, maintenance	.....	.....	**.0179–.0358**	**.0065–.0109**
1.5-lb. daily gain	.....	.....	**.0375**	**.0183**
			.0554	**.0248**
Growing ration,‡ using timothy hay, grain	.....	.....	.0322	.0345
0.058 lb. $CaCO_3$ with 3.5 lb. grain	.....	.....	.0232	.....
			.0554	
Therefore 1.66% $CaCO_3$ in grain mixture is needed to supply Ca.				

* Timothy hay 10 pounds, corn silage 30 pounds, grain mixture 10 pounds (corn 3.5, oats 2.0, wheat bran 2.0, linseed meal 2.5 pounds).

† Alfalfa hay 10 pounds, corn silage 30 pounds, grain 10 pounds (corn 5.5, oats 3.0, wheat bran 1.5 pounds).

‡ Timothy hay 10 pounds, grain mixture 3.5 pounds (corn 2, linseed meal 1.5 pounds).

specifies 100 grams CaO (71.5 grams Ca) and 50 grams P_2O_5 (21.8 grams P) for the maintenance of 1000 kg. live weight, which therefore amounts to .0715 pound (32.5 grams) Ca and .0218 pound (10 grams) P for every 1000 pounds live weight. For every pound of milk produced, he adds to the above .0018 pound Ca and .0011 pound P.

According to the above Kellner standard, dairy rations made up of timothy hay, corn silage, and a grain mixture to balance the ration, using average figures for mineral composition (44), in the case of lactating cows would require about 2 per cent $CaCO_3$ or high calcium ground limestone added to the grain mixture. More or less than that amount would need to be added depending on the amount of grain fed or the level of milk production. The Florida workers (7) compared the specifications of the Kellner and Wellmann standards for calcium and phosphorus, and these standards are made use of in table 1 for testing the adequacy for calcium and phosphorus of common American dairy rations.

It is seen that by these two European standards it would be necessary to add calcium to timothy hay and corn silage rations, using average figures of composition. Where legume hay makes up one-half or more of the roughage, the required calcium is well supplied.

However, dairy rations that have a large portion of the necessary protein furnished by legume roughage such as alfalfa or by one of the protein concentrates which is relatively low in phosphorus, such as corn gluten meal, barely satisfy the minimum phosphorus requirement of the Wellmann standard for either growth or milk production. They do meet the Kellner standard for phosphorus.

It is seen from table 1 that, considering average composition of a number of typical American feeds, there is according to both European investigators a shortage of calcium where grass hay and corn silage are the roughages in the ration. The amounts of $CaCO_3$ necessary with such rations range from 1.6 to 2.1 per cent of the grain mixture, assuming more or less normal grain allowances in keeping with milk production. With legume hay and a modest proportion of protein concentrates in the grain mixture, the phosphorus requirement was met and the calcium requirement amply met. But without a protein concentrate it was necessary to add bone meal or other carrier of phosphorus to the ration in order to satisfy the standard.

In the light of American experience and the long-time feeding experiments in this country, which have been referred to, there is no need to fear a calcium deficiency in dairy rations except where timothy or grass hay, or low protein roughage in general has been grown on acid soil. The timothy or other grass would be still lower in calcium if cut at too mature a stage of growth and thereupon cured or stored under unfavorable conditions. A calcium deficiency is a relatively rare or regional problem (7). Kellner and Wellmann in retrospect seemed unduly concerned over this matter when they

hold that dairy rations are deficient in calcium more frequently than in phosphorus (63). If the old Wolff or the Wolff-Lehmann feeding standard for dairy cows may be taken as an example, the cattle in the particular European countries concerned seem all along to have been given generous allowances of oil meals, mill feeds, or other protein concentrates, which more or less automatically supply an abundance of phosphorus. Such European practices and experiences, therefore, would differ sharply from the experiences of cattle raisers on the South African veld or on some of our western ranges or other extensive cattle raising areas of the world where cattle grow and subsist very much more exclusively on range forage and a minimum of concentrates. Calcium is far from being the main concern of ranchmen or, for that matter, dairymen in this country.

A calcium deficiency may be a problem where non-legume roughage grown on rather unproductive acid soil (7) makes up the roughage of the ration. A relatively large intake of concentrates rich in phosphorus might then aggravate an imbalance of the two minerals involved. Or with a minimum amount of roughage of any sort and a maximum amount of grain and oil meal or mill feed, growing cattle may in time show a calcium deficiency.

PHOSPHORUS

Deficiencies of phosphorus among ruminants or herbivorous animals far outnumber deficiencies of calcium. As one evidence of this situation, most countries of the earth have certain names or designations for phosphorus deficiency diseases whereas they do not have a similar array of terms for calcium deficiency diseases. To list a few names for aphosphorosis: Pica, styfsiekte, loin disease, creeps, stiffs, sweeny, peg-leg, cripples. Theiler, Green, and du Toit (58) of South Africa, solved in a rather dramatic way the cause of lamsiekte, or bovine botulism, by tracing this pathogenic disease to a deficiency of phosphorus in the soil and therefore in the range forage. The disease was contracted by cattle having a depraved appetite, chewing carcasses and bones of cattle that had succumbed to the disease. In this way the living cattle contracted the disease because of their craving for phosphorus induced by a deficiency in the range forage growing on phosphorus-deficient soil. Feeding bone meal or other form of phosphorus prevented the disease.

Subsequently a number of phosphorus-deficient areas have been identified in many countries, including this country, in the states of Texas (53), Wisconsin (25), Minnesota (15), Pennsylvania (23), Florida (6), and a number of other states. As in South Africa (13) the administration of bone meal or other phosphate has cured or prevented the difficulty (54). While hardly feasible in the range country, it is entirely feasible and practical to apply phosphate fertilizer on the more intensively managed dairy farms of the country.

Pica or depraved appetite is prevalent where the soil is low in available phosphorus and where cattle subsist mainly or entirely on roughages as do range cattle or as may dairy cattle. The addition of grain, particularly protein concentrates, raises the phosphorus level in the ration considerably. But in the absence of such a protein concentrate some other phosphorus carrier like bone meal must be fed to assure a sufficiency of this element for growth, gestation, and milk production. The South African workers (9) have found it practicable to dissolve phosphates in drinking water for range cattle.

The necessity for added phosphorus was demonstrated at the Michigan Experiment Station by Huffman and co-workers (34) using a ration including alfalfa hay containing less than 0.20 per cent phosphorus, corn silage with a still lower, and corn with a somewhat higher phosphorus content. This ration of about 0.20 per cent phosphorus of the entire ration on the dry matter basis caused an immediate lowering of the inorganic blood phosphorus which is a satisfactory and early symptom of a phosphorus deficiency. The occurrence of this blood condition usually preceded anorexia. They did not find a depraved appetite a reliable index of phosphorus deficiency. The Michigan workers state that during the winter months when there are very few ultraviolet rays in sunshine, there may be interference with phosphorus utilization when the phosphorus level in the ration is low. In Pennsylvania (23) cases of phosphorus deficiency were found more frequently when cattle were wintered on cereal straw and corn stover. The investigators state that absence of sunshine "serves to aggravate the effect of a phosphorus deficiency."

These observations suggest that there may be a number of factors playing a part in phosphorus utilization, not merely the phosphorus content of the feed, but also digestion and assimilation which latter is also affected by parathyroid activity. Much of the phosphorus in grains and concentrates is in the form of phytin which in experimental rat feeding and with humans has not been metabolized very efficiently (38). Nevertheless in practical rations and in the presence of phytin-splitting enzymes in the blood and livers, this phosphorus compound has proved an efficient source of phosphorus for farm animals (29).

Huffman and associates (34) after extensive feeding experiments with various dairy rations supplemented and unsupplemented with phosphorus compounds, recommend that milking cows be provided with 10 grams of phosphorus (the Kellner standard) in their ration for every 1000 pounds live weight, that for every pound of milk produced they receive 0.75 gram phosphorus in their ration, and that not less than 17 grams phosphorus should be fed during low production and during the dry period. This amount of phosphorus would be amply supplied by common rations that are recognized as satisfactory, such as the rations for milking cows indicated in

the foot-note of table 1, which have .26 or .27 per cent phosphorus on the air-dry basis, where only about .24 per cent phosphorus in the ration as a whole would be necessary. Such rations, instead of 0.75 gram phosphorus, supply from about 0.9 to 1.1 gram phosphorus for each pound of milk in addition to maintenance. As milk production increases, the percentage of phosphorus must increase. Thus, where according to the above standard a 1200-pound cow giving 30 pounds of milk daily would need about 0.24 per cent phosphorus in her ration, if she gave 60 pounds of milk she would need about 0.30 per cent phosphorus in her ration, on the air-dry basis.

Obviously, if the ration consisted of alfalfa hay alone, which may have only about 0.21 per cent phosphorus, or if corn silage or beet pulp or limited amounts of corn were fed with it, this might bring on a phosphorus deficiency in milking cows. Practical ways of supplying phosphorus would be adding 1 or 2 per cent bone meal to the grain mixture, or having at least 20 per cent of such phosphorus-rich protein concentrates as wheat bran, cottonseed meal, or linseed meal in the grain mixture.

An uncomplicated phosphorus deficiency (16) was brought on by Minnesota workers feeding for 2 to 3 years a ration of prairie hay which on the average had only about 0.07 per cent phosphorus, and a grain mixture in which corn gluten meal was the only protein concentrate used. As a result of this ration, the inorganic phosphorus of the blood plasma of the cows fell to about one-half of the normal level, or to about 2.5 mgm. per cent, this response being an indication of aphosphorosis. This ration did not cause abnormal estrum although it did appear to reduce breeding efficiency.

Many times in the field a phosphorus deficiency is combined with a protein deficiency (49). Uncomplicated phosphorus deficiencies have delayed sexual maturity and have repressed evidences of estrum, but have not prevented ovulation and conception. They did not prevent normal vigor in new-born calves, though the dams were "undersized, miserable appearing specimens." Four out of 8 of the cows had difficulty in parturition.

THE RELATIONSHIP OF CALCIUM AND PHOSPHORUS

Calcium and phosphorus usually are discussed together because of their natural affinity throughout nature and in animal nutrition. However, in the nutrition of dairy cattle the two elements can be discussed independently more satisfactorily than in the nutrition of pigs or some other animals that subsist largely on grains or concentrates, especially if such animals should be deprived of vitamin D as supplied by outdoor sunshine or by its presence in the ration. This recognizes the partnership existing between the two mineral elements and vitamin D where the latter serves a corrective calcifying function when either or both of the two elements are present in sub-optimal amounts. In the absence of vitamin D, if it can be spared at all with some species of animals, the two elements must be present in nearly the right

amounts and proportions for optimum results. But with an abundant amount of vitamin D present, some rather wide departures from the optimum are permissible.

Possibly because of consuming liberal amounts of sun-cured hay, if they are not themselves exposed to outdoor sunlight (39), possibly because of species difference as a factor, cattle do not require a rigid Ca : P ratio in their ration. Rather it is necessary that either of the two minerals be present in at least minimum necessary amounts, then the body metabolism within rather wide limits takes care of the surplus amount of the other element. Nevertheless it has been suggested that from 1 to 2 parts of calcium to every 1 part of phosphorus is the desirable relationship. Ca : P ratios as extreme as 4 : 1 or wider have been fed to both growing (14) and mature (34) cattle with apparent success. Alfalfa hay thus has a ratio of about 7 : 1. Feeding alfalfa hay alone sets a rather low limit to milk production (33) unless the cows are fed bone meal or other source of phosphorus (24, 36). The feeding of most any grain or concentrate with alfalfa would narrow the ratio. In mineral balance studies at Vermont (18) cows could be fed large amounts of calcium where for some weeks the cows were on a negative calcium balance. Still there was no interference with the utilization of the phosphorus.

Cows are also rather insensible to exposure to sunlight or ultraviolet light in so far as redeposition of calcium and phosphorus or checking a negative balance is concerned (27, 30). When definitely rachitic (60), cows have proved responsive to vitamin D administration by various means. Also milk produced by cows on pasture, with the animals therefore exposed to an abundance of ultraviolet light, proved richer in vitamin D than milk produced during the winter when the cows were kept largely in the barn (12, 41, 61). The relative prevalence of milk fever during winter months when solar radiation is poorest may also indicate the existence of a greater responsiveness to sunshine on the part of the cows than has been held to be the case.

Calves tolerate a rather large proportion of calcium to phosphorus. At Wisconsin (51) calves grew better on a Ca : P ratio of 3 : 1 than 1.5 : 1. According to Sheehy and Senior (56), it is advisable to add calcium to the ration of calves when the Ca : P ratio is less than 1.64 : 1 and that by correcting the balance in this way the retention of phosphorus is raised. When poor hay was fed, cod-liver oil raised the retention of calcium and phosphorus, but was not otherwise necessary. Du Toit and co-workers (14) also found that a Ca : P ratio of 7.7 : 1 produced as good results with calves as one of 1.17 : 1. The practice of feeding lime in some form to calves may have a sound nutritional basis.

That cows during most of their lactation are not very acquisitive in respect to a number of nutrients, including minerals, was proved by the work of Forbes and associates (21, 22), and Ellenberger and associates (17, 18) with cows which during the flush of milk production were on a negative

calcium and phosphorus balance, and replenished their stores only during the drying off and the dry period. The cows obviously used their skeletons as a reserve for those minerals and doled them out to the milk. It has been stated that while the flood gates of milk production were open, it was difficult to push minerals upstream, as might be attempted by feeding added minerals in the ration.

This cycle is to be looked upon as a normal one which emphasizes the importance of the dry period. A cow at that time should store not merely visible reserves by way of body fat, but also invisible reserves, the minerals and vitamins. Too often a dry cow is looked upon as essentially in cold storage. But her ability to produce milk during the following lactation depends in large part on the quality of her feed, including minerals (1, 42).

Mineral feeding standards relating to calcium and phosphorus have been discussed and the mineral contents of rations that are practical in many dairy sections have been checked against them, showing that the European standards were rather high in their calcium specification. Dairy rations making extensive use of legume roughage in many cases seemed low in phosphorus, especially in high-producing cows. Considerable dependence naturally would be placed on long-time mineral feeding experiments. Such experiments have been conducted, among others, at Michigan (50), Ohio (32), Pennsylvania (4, 20), Massachusetts (40), and Wisconsin (26), all of them showing that with the feeding of rations that were practical on dairy farms of those states, no additional calcium or phosphorus was necessary. The herds of cows used on these experiments were for the most part such as would be representative of the better dairy herds of the region and did not include many high-producing cows. Such cows will probably always need special attention in respect to all of the nutrients.

Likewise in areas where through soil deficiencies or for weather or climatic reasons the roughages should be deficient in calcium, phosphorus, or other minerals, suitable additions to the ration may need to be made.

Where grasses or cereal forages constitute the roughage part of the ration, and where the grain mixture of necessity needs to be fortified with protein concentrates, a possible lime deficiency of the ration as a whole may need to be kept in mind, but such a deficiency seems surprisingly remote in the light of experimental findings in this country. However, forages grown on acid soils, particularly acid sandy soils, may present such a calcium problem.

Any time legumes make up a large part of the roughage, only phosphorus is likely to be deficient, and then only provided the roughage has been grown on phosphorus-deficient soil and is fed with a minimum amount of grain or concentrates. When such protein concentrates as wheat bran, linseed meal, and cottonseed meal are fed to the extent of 20 per cent of the grain mixture, and the grain mixture is fed in usual amounts in relation to milk production, phosphorus is well supplied.

In consideration of the findings at various American experiment stations, and mindful of earlier work abroad, Mitchell and McClure estimated mineral requirements of growing dairy heifers, gestating cows, and milking cows, as given in tables 2, 3, and 4. The computation of the percentages of the two mineral ingredients in the dry ration, which computation was derived from the "grams required intake," presupposes a certain feed intake for which the provisions of the Morrison feeding standards were used. A percentage relationship of total digestible nutrients to the dry matter of the ration was assumed and was used for all three tables in those columns in which the percentages calcium or phosphorus of the dry ration are indicated:

TABLE 2

Estimated calcium and phosphorus requirements of growing Holstein-Friesian cattle (female)

From H. H. Mitchell and F. J. McClure (43)

Body weight	Feed calcium required	Necessary percentage of calcium in dry ration	Feed phosphorus required	Necessary percentage of phosphorus in dry ration
lbs.	*grams*	*per cent*	*grams*	*per cent*
300	11.3	0.33	10.3	0.30
400	10.4	0.27	10.4	0.27
500	9.4	0.21	10.4	0.24
600	8.7	0.18	10.4	0.22
700	7.7	0.15	10.3	0.20
800	7.1	0.13	10.3	0.19
900	6.4	0.11	10.3	0.18
1000	5.9	0.10	10.3	0.17
1100	5.6	0.08	10.6	0.16
1200	5.4	0.08	10.9	0.16

If the provisions for a growing heifer or for a 1000-pound cow giving 30 pounds milk are checked against the corresponding provisions by Kellner and Wellmann in table 1, it will be seen that all of the unsupplemented rations would have satisfied this newer standard. This means in general that rations made up of feeds of average composition do not need added bone meal or calcium carbonate.

Table 2 shows that heifers which presumably were to be managed in a practical manner, having outdoor exercise and sunlight, should get along on a ration made up of commonly used feeds. At an early stage of growth the percentage of both calcium and phosphorus needs to be fairly high, as would be provided by using legume hay for at least part of the roughage and by using protein concentrates to balance the ration. Beyond about 600 pounds live weight a rather ordinary ration of roughage and grain supplies the necessary amounts of the two minerals.

Not, however, if this heifer should be in calf, for then according to table 3 both the calcium and phosphorus requirements increase quite rapidly toward the final months of gestation. The ration would need to include

TABLE 3

Estimated calcium and phosphorus requirements of a pregnant Holstein-Friesian cow weighing 1000 pounds
From H. H. Mitchell and F. J. McClure (43)

Month of gestation	Feed calcium required daily	Necessary calcium in dry ration	Feed phosphorus required daily	Necessary phosphorus in dry ration
	grams	*per cent*	*grams*	*per cent*
4	6.0	0.10	10.4	0.17
5	6.4	0.10	10.7	0.17
6	7.6	0.12	11.6	0.18
7	10.4	0.16	13.3	0.21
8	12.4	0.19	16.3	0.25
9	27.9	0.42	20.4	0.31
Average	11.8	0.18	13.8	0.22

the kind of roughage and grain or concentrate mixture that equals in quality, not in quantity, the rations fed to cows of good production.

The mineral specifications for milk production are given in table 4. It will be appreciated from the figures for calcium and phosphorus that, in the light of previous discussion of these two minerals, their necessary percentages in the ration are such as would be taken care of by common feeds of average composition. For the production of milk of varying fat content, allowances are made and larger amounts of calcium and phosphorus are specified for increasing richness of the milk in both butterfat and solids-not-fat.

TABLE 4

Estimated calcium and phosphorus requirements of 1000 pound Holstein-Friesian cows producing varying amounts of 3.5 per cent milk
From H. H. Mitchell and F. J. McClure (43)

Daily milk production	Feed calcium required daily	Necessary calcium in dry ration	Feed phosphorus required daily	Necessary phosphorus in dry ration
lbs.	*grams*	*per cent*	*grams*	*per cent*
10	12.7	0.16	15.7	0.20
20	19.6	0.21	21.1	0.23
30	26.4	0.24	26.6	0.25
40	33.3	0.27	32.0	0.26
50	40.1	0.29	37.4	0.27
75	57.3	0.32	51.0	0.29
100	74.4	0.35	64.6	0.30

In the light of the more or less generally accepted desirable Ca : P ratio of 1 to 2 : 1, the question may be raised why in every case except for the three conditions of early growth, the last stages of gestation, and high milk production, the Ca : P ratio is less than unity.

OTHER MINERALS

Salt (NaCl) is used almost universally in dairy cattle rations, and its importance has been duly recognized for ages. The need for salt was emphasized by an experiment by Babcock (2) who withheld salt from one-half of a dairy herd with the result that in time these animals presented a strikingly adverse contrast to the other half of the herd. The salt-starved cows ran down badly in condition, they decreased in milk production, and failed to deliver normal calves. Babcock's recommendation for feeding salt was to allow $\frac{3}{4}$ ounce salt daily per 1000 pounds live weight and in addition 3/10 ounce salt for every 10 pounds of milk produced. Feeding the customary one per cent salt in the grain mixture and feeding grain in the usual proportion to milk provides most milking cows with enough salt during the larger part of the lactation period, but may not take care of their need for salt during the drying off or dry period, nor any time their grain allowance should be greatly restricted in favor of more roughage. A reasonable arrangement is to allow all members of the herd free access to salt in addition to any that may be mixed with the grain. Records kept of the salt consumption of individual cows have shown great differences (11) and suggest that the need for salt by individual cows differs greatly.

Iodine deficiencies appear to be confined to some of the northwest states and to the Great Lakes region. The statement that iodine makes for improvement in the nutrition of cattle in areas outside of these regions, has not been generally accepted. Where "big neck" calves have occasionally been born, iodine in some form should be fed, the most convenient method being the feeding of iodized salt.

Copper and iron (5) deficiencies in cattle have shown up in parts of Florida where cattle subsisted on forage grown on sandy soil which was extremely low in organic matter. Such occurrences may be found on other similarly constituted soil but need not prompt the practice of incorporating iron and copper in the rations of dairy cattle elsewhere.

A disease among cattle in the Grand Traverse region of Michigan, which disease for some time had been considered a phosphorus deficiency disease, during the past few years has been identified as due to a low level of cobalt in the roughages grown in that and some other counties bordering Lakes Michigan and Huron (3). Cobalt-deficient areas have been identified along the coastal plains from Texas to the Carolinas, including Florida (45). Australia and New Zealand stockmen and research workers have known of this disease for some years.

The question of a possible lack of manganese in dairy rations has been raised, especially by research workers in dairy cattle reproduction. It has been appreciated for some time that manganese plays a role in some of the phases of reproduction. It has been found by Michigan workers (52) that

feeds differ greatly in their manganese contents and that the factors of soil types and soil reactions, and maturity of crops greatly affect the level of manganese in those crops. The place of manganese and the question of any necessary fortification of manganese in dairy cattle rations await an answer.

Magnesium in sub-normal amounts or in an imbalanced relationship with other mineral elements seems to play a part in grass tetany, but the magnesium picture as yet is not clear.

PRACTICAL CONSIDERATIONS

From the foregoing discussion it appears that minerals in dairy cattle nutrition present a problem in areas where the soil is low in available mineral elements, in some cases being an acid sandy soil, in others a soil of various types that has been cropped without adequate restitution. Except in a range country where phosphating or other manner of fertilizing is impractical, the way out of most mineral deficiencies among cattle is to feed the necessary elements to the soil and thus indirectly to the animals subsisting on the products of the soil.

With rare exceptions feed crops, especially roughages that have been grown on fertile soil, are well supplied with those minerals of which the animal organism is directly in need. Thus the lime and phosphorus need of cows in liberal milk flow may be met by home-grown roughages and grains, especially when supplemented with such protein concentrates as may be necessary to balance the ration.

The ability of cows to store calcium and phosphorus in their skeletons against the day of need for milk production is reassuring. But a knowledge of this cycle in the physiology of cows should also be a warning to the owner to give cows a reasonably long dry period, and during that time to give them every chance to store the invisible reserves, the minerals and vitamins, as well as to put fat on their bodies.

Natural feeds that make up a ration are complex in their mineral composition and except for rare instances, or restricted geographical areas, satisfy the mineral requirement of cattle without the need of resorting to complex mineral mixtures. With the exception of salt, and in places iodine as may be supplied by iodized salt, the mineral which is most likely to be present in too small amounts in a dairy ration, is phosphorus. A calcium deficiency is rare and is almost precluded if any considerable proportion of the roughages is of a legume character.

This, essentially, appears to be the situation in respect to the need of dairy cattle for minerals. But adding minerals to dairy feeds is common practice. Also the mineral preparations, whether home-mixed or offered by the trade, usually contain from about 4 to 6 times as much calcium as phosphorus (10). Calcium obviously is many times cheaper than phosphorus

and this fact probably has a bearing on the situation. Reasoning from the facts presented, cows have a tolerance for a large amount of calcium and for a wide calcium: phosphorus ratio. They probably are not injured by a high intake of calcium in the form of legume hay plus additional ground limestone, or $CaCO_3$, except as suggested by Eckles and co-workers (15) when cattle are on sub-optimal intakes of phosphorus.

A sensible way of feeding minerals to dairy cattle is feeding about 1 per cent salt or iodized salt, if necessary, in the grain mixture and in addition, perhaps in a suitably protected box in the exercise yard or the pasture, some additional salt freely accessible to the animals. Then, if the owner should be worried about a possible deficiency, he might offer some bone meal or other suitable phosphate alongside the salt box. It may be desirable to mix from 10 to 20 per cent salt with the bone meal to make it more palatable, but the cattle should not be obliged to eat bone meal when they actually wish to eat salt. Where with the above arrangement (46) cattle have been given in addition free access to ground limestone, they have under normal conditions eaten extremely little limestone and only very little bone meal. Such has been common experience even where herds have consisted of medium to high producing cows.

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PROGRAM

THIRTY-SEVENTH ANNUAL MEETING

OF THE

AMERICAN DAIRY SCIENCE ASSOCIATION

MICHIGAN STATE COLLEGE
EAST LANSING, MICHIGAN

JUNE 22–25, 1942

PROGRAM COMMITTEE

MANUFACTURING

E. H. PARFITT, Evaporated Milk Association (*Chairman*)
P. F. SHARP, New York
O. F. GARRETT, New Jersey

EXTENSION

J. F. KENDRICK, Bureau Dairy Industry (*Chairman*)
E. C. SCHEIDENHELM, Michigan
A. C. BALTZER, Michigan

PRODUCTION

H. A. HERMAN, Missouri (*Chairman*)
W. E. PETERSEN, Minnesota
K. L. TURK, Maryland

GENERAL

H. W. CAVE, Oklahoma (*Chairman*)
E. H. PARFITT, Evaporated Milk Association
H. A. HERMAN, Missouri
J. F. KENDRICK, Bureau of Dairy Industry

REGISTRATION

LOBBY—ABBOT HALL (*Men's Dormitory*)

Saturday	9:00 a.m.– 1:00 p.m.
Sunday	2:00 p.m.– 9:00 p.m.
Monday	8:00 a.m.– 9:00 p.m.
Tuesday	8:00 a.m.– 7:00 p.m.
Wednesday	8:00 a.m.– 5:00 p.m.
Thursday	8:00 a.m.–12:00 m.

COMMITTEE MEETINGS

ROOM ASSIGNMENTS AND TIME OF MEETINGS

The Breed's Relations Committee is requested to meet at 8:00 A.M. on Tuesday, June 23, in Room 235, Abbot Hall.

The following committees are requested to meet at 11:00 A.M. on Tuesday, June 23, in the rooms as indicated—all in Abbot Hall:

Room 35—Feeds Specifications. E. S. SAVAGE, *Chairman.*

Room 236—Measuring Results of Pasture Investigations. G. BOHSTEDT, *Chairman.*

Room 335—Silage Methods, Evaluation, etc. C. B. BENDER, *Chairman.*

Room 336—Rules for Dairy Cattle Judging Contest. I. W. RUPEL, *Chairman.*

Grill—Awards for Dairy Cattle Judging Contest. A. A. BORLAND, *Chairman.*

The following are proposed as suitable rooms for other groups which may desire to meet. Reservation of rooms should be made with C. F. Huffman.

In Abbot Hall:

Room 135—(Manufacturing) Quality of Milk and Milk Products.

Room 136—(Manufacturing) Methods for Analysis of Milk and Dairy Products.

Library—Board of Directors.

Lower lounge—Other Production Section committees.

Play room—Extension Section committees.

In Mason Hall:

Lower lounge—Other Manufacturing Section committees.

SCHEDULE OF PROGRAM (Eastern War Time)

Time	General	Extension Section	Production Section	Manufacturing Section
Mon., June 22				
12: 00	Lunch, Parchment, Michigan			
1: 30– 3: 30	Tour of KVP plant			
Evening 8: 00	Committees			
Tues., June 23				
9: 00–11: 00	Opening session			
11: 00–12: 00	Committees	Committees	Committees	Committees
12: 00– 1: 30	Barbecue			
1: 30– 4: 00		Joint symposium		Symposium
4: 00– 6: 00		Tour of experimental barn and pastures		Judging dairy products (milk)
Evening 9: 00	Reception and Entertainment			
Wed., June 24				
9: 00–11: 00		Business and papers	Papers—Div. A, B	Papers
11: 00–11: 45	Committees	Committees	Committees	Committees
11: 45–12: 00	Group Picture			
1: 30– 3: 30		Papers	Papers—Div. A, B	Symposium
3: 30– 4: 30		Business	Business	Business
4: 30– 6: 00		Demonstration of practices in mastitis control—main dairy barn		Judging dairy products (ice cream)
6: 00	Fish Fry			
Evening 8: 00	Entertainment, Don Cossack Male Chorus			
Thurs., June 25				
9: 00–11: 00		Joint symposium		Papers
11: 00–12: 00		Business	Business	Business
1: 30– 3: 30		Exhibits and papers		Joint symposium
3: 30– 5: 00	Business			
Evening 6: 30	Association banquet			
Fri., June 26				
9: 00	Post-convention trip, Dearborn, Michigan (tentative)			
11: 00	Visit Ford Museum			
12: 30	Luncheon			
2: 00	Visit Greenfield Village			

PROGRAM FOR WOMEN

Monday, June 22

12:00	Luncheon at K.V.P. Community House, Parchment, Michigan. *Compliments of Kalamazoo Vegetable Parchment Company.*
1:30	Tour of K.V.P. Plant. (*Those not traveling by car will have convenient bus connections to East Lansing.*)

Tuesday, June 23

12:00	Barbecue—*Compliments of Ayrshire Breeders' Association and Michigan State College.*
3:00	Tea and Social Gathering.
Evening 9:00	Reception and Entertainment.

Wednesday, June 24

9:30	Tour Beal Botanical Gardens.
10:30	Tour Forestry Nursery.
3:00	Demonstration—Floral Table Arrangements.
6:00	Fish Fry—Abbot Hall.
Evening 8:00	Entertainment—Don Cossack Male Chorus, Main Auditorium.

Thursday, June 25

1:00	Luncheon and Bridge.
6:30	Banquet—Ballroom, Union Building.

Friday, June 26

9:00	Post Convention Trip, Dearborn, Michigan (subject to final decision regarding opening of Greenfield Village in 1942).
11:00	Visit to Ford Museum—*Admission, Compliments of Borden Farm Products Company.*
12:30	Luncheon—*Compliments of National Dairy Products Corporation.*
2:00	Visit Greenfield Village—*Admission, Compliments of Borden Farm Products Company.*

Women are particularly invited to attend the opening session of the General Program. They also will be welcome at any of the Section Programs.

FOR THE CHILDREN

Supervised tours, picnics, swimming, canoeing, tennis, playground and other entertainment.

GENERAL PROGRAM

(Eastern War Time)

Monday, June 22

12:00 **Lunch at K.V.P. Community House,** Parchment, Michigan (north edge of Kalamazoo). *Compliments of Kalamazoo Vegetable Parchment Company.*

1:30– 3:30 **Tour of K.V.P. Plant.** (Those not traveling by car can have convenient bus connections to East Lansing.)

Evening 8:00 Committees.

Tuesday, June 23

9:00–11:00 OPENING SESSION. FAIRCHILD THEATER.

Call to Order—EARL WEAVER, *Head, Department of Dairy Husbandry, Michigan State College.*

Introductions—Officers of American Dairy Science Association. H. F. JUDKINS, *President.*

Past Presidents. H. P. DAVIS, *Vice-President.*

Past Directors. R. B. STOLTZ, *Secretary.*

Address of Welcome—J. A. HANNAH, *President, Michigan State College.*

Response and Address—H. F. JUDKINS, *President, American Dairy Science Association.*

The Foster Mother—O. E. REED, *Chief, Bureau of Dairy Industry.*

Announcements.

11:00–12:00 **Committees.**

12:00– 1:30 **Barbecue**—*Compliments of Ayrshire Breeders' Association and Michigan State College.*

Evening 9:00 **Reception and Entertainment**—Lobby, Abbot Hall.

Wednesday, June 24

11:00–11:45 **Committees.**

11:45–12:00 **Group Picture.**

Evening 6:00 **Fish Fry**—Abbot Hall.

8:00 **Entertainment—Don Cossack Male Chorus, Main Auditorium.**

Thursday, June 25

3:30– 5:00 **Business Session**—Fairchild Theater.

Evening 6:30 **Annual Association Banquet—Presentation of Borden Awards,** Ballroom, Union Building.

Friday, June 26

9:00 **Post-Convention Trip,** Dearborn, Michigan (subject to final decision regarding opening of Greenfield Village in 1942).

11:00 **Visit Ford Museum**—*Admission, Compliments of Borden Farm Products Company.*

12:30 **Luncheon**—*Compliments of National Dairy Products Corporation.*

2:00 **Visit Greenfield Village**—*Admission, Compliments of Borden Farm Products Company.*

SECTIONAL PROGRAMS

EXTENSION SECTION

June 22–25

Exhibits—Display of Extension Teaching Ideas, Playroom, Abbot Hall

Tuesday, June 23

1:30–4:00 P.M.—Lower Lounge, Abbot Hall
PAUL PHILLIPS, *Chairman*

Symposium

Nutrition and Reproduction in Dairy Cattle.
Joint session of Extension and Production Sections.

A—The role of minerals in reproduction. R. B. Becker, University of Florida.

B—Vitamin E and reproduction. H. B. Thomas, Iowa State College.

C—Vitamin A and its relationship to reproduction with special reference to cattle. T. S. Sutton, Ohio State University.

D—The role of Vitamin C in reproduction. H. A. Lardy, University of Wisconsin.

4:00–6:00 P.M.
Tour of Experimental Barn and Pastures—Experimental Barn
Judging Dairy Products (Milk)—Room 211, Dairy Building

Wednesday, June 24

9:00–11:00 A.M.—Playroom, Abbot Hall
GLEN W. VERGERONT, *Chairman*

Business Session

Announcements and appointment of committees.

Testing Committee Report

R. W. DICKSON, *Chairman of Committee (In charge)*

A—Maintaining qualified tester personnel. A. J. Cramer, University of Wisconsin.

B—Supervisory problems. E. H. Loveland, University of Vermont.

C—Emergency adjustment in D.H.I.A. procedure. C. R. Gearhart, Pennsylvania State College.

D—Current developments affecting D.H.I.A. J. B. Parker, U. S. Bureau of Dairy Industry.

E—Recommendations of Committee.

Sire Committee Report

E. J. PERRY, *Chairman of Committee (In charge)*

A—Interpreting and using proved-sire data effectively. R. G. Connelly, Virginia Polytechnic Institute.

B—Present day techniques of artificial insemination. Geo. W. Trimberger, University of Nebraska.

C—Storing, packaging and shipping semen. Leland Lamb, American Dairy Cattle Club.

D—Recommendations of Committee.

Dairy Cattle Health Committee Report

GEO. E. TAYLOR, *Chairman of Committee (In charge)*

A—Recommendations of Committee.

1:30–3:30 P.M.—Playroom, Abbot Hall

Feeding Committee Report

C. L. BLACKMAN, *Chairman of Committee (In charge)*

A—Simple vs. complex rations for dairy cattle. C. F. Monroe and W. E. Krauss, Ohio Experiment Station.

B—Recommendations of Committee.

Dairy Farm Records Committee Report

L. G. GILMORE, *Chairman of Committee (In charge)*

A—Recommendations of Committee.

Type Rating Committee Report

J. W. LINN, *Chairman of Committee (In charge)*

A—Recommendations of Committee.

4–H Dairy Club Committee Report

H. A. WILLMAN, *Chairman of Committee (In charge)*

A—Recommendations of Committee.

Quality and Marketing Committee Report

EVERT WALLENFELDT, *Chairman of Committee (In charge)*

A—The need for quality improvement. H. R. Searles, University of Minnesota.

B—Methods and organization of dairy manufacturing extension. C. J. Babcock, U. S. Bureau of Dairying.

C—Dairy manufacturing activities devoted to national defense. J. M. Jensen, Michigan State College.

D—Recommendations of Committee.

Business Session

3:30–4:30 P.M.—Playroom, Abbot Hall

4:30–6:00 P.M.

A—Demonstration of practices in mastitis control—Main Dairy Barn

B—Judging dairy products (ice cream)—Room 211, Dairy Building

Thursday, June 25

9:00–11:00 A.M.—Lower Lounge, Abbot Hall

Symposium

Input as Related to Output in Milk Production

See Production Section program.

11:00–12:00 M.—Playroom, Abbot Hall

GLEN W. VERGERONT, *Chairman*

Business Session

1:30–3:30 P.M.—Playroom, Abbot Hall

Exhibit Committee Report

C. A. HUTTON, *Chairman of Committee (In charge)*

A—Discussion of exhibits.

B—Recommendations of Committee.

PRODUCTION SECTION

Tuesday, June 23

1:30–4:00 P.M.—Lower Lounge, Abbot Hall

Symposium

Nutrition and Reproduction in Dairy Cattle (See Extension Section)

4:00–6:00 P.M.—Experimental Barn

Tour of Experimental Barn and Pastures

Wednesday, June 24

9:00–11:00 A.M.—See Divisions A and B
1:30– 3:30 P.M.—See Divisions A and B
3:30– 4:30 P.M.—Lower Lounge, Abbot Hall

Business Session

4:30–6:00 P.M.—Main Dairy Barn
Demonstration of Practices in Mastitis Control

Thursday, June 25

9:00–11:00 A.M.—Lower Lounge, Abbot Hall
K. L. TURK, *Chairman*

Symposium

Input as Related to Output in Milk Production.
Joint session of Production and Extension Sections.

A—Results of cooperative experiments to determine input–output relationships in milk production—
Einar Jensen, U. S. Bureau of Agricultural Economics
T. E. Woodward, U. S. Bureau of Dairy Industry

B—Practical application of the experimental results—
Discussion (Brief reports by cooperating stations)
A. E. Tomhave, Delaware; J. H. Hilton, Indiana;
K. L. Turk, Maryland; R. E. Horwood, Michigan;
J. S. Moore, Mississippi; C. B. Bender, New Jersey;
A. C. Dahlberg, New York (Geneva); A. A. Borland, Penn.;
T. M. Olson, South Dakota; A. D. Pratt, Virginia.

C—What new knowledge has been contributed by the input–output investigations.
F. B. Morrison, Cornell University.

D—Discussion.

Business Session

11:00–12:00 M.—Lower Lounge, Abbot Hall

Business Session

1:30–3:30 P.M.—Lower Lounge, Abbot Hall
H. P. DAVIS, *Chairman*

Symposium

Curricula—Joint session with Manufacturing Section.

PRODUCTION SECTION—DIVISION A

Wednesday, June 24

9:00–11:00 A.M.—Lower Lounge, Abbot Hall

H. A. HERMAN, *Chairman*

Nutrition and Herd Management

P1—Improving dairy cattle pastures. W. B. Nevens, University of Illinois.

P2—The ability of yearling heifers to withstand cold temperatures. J. R. Dice, North Dakota Agricultural Experiment Station.

P3—Resting maintenance cost in growing dairy cattle. Samuel Brody, University of Missouri.

P4—Occurrence and importance of still unidentified nutrients in milk and milk products. A. M. Hartman and C. A. Cary, Bureau of Dairy Industry, U.S.D.A.

P5—Hydroxyamino acids in milk proteins. B. H. Nicolet, L. A. Shinn and L. J. Saidel, Bureau of Dairy Industry, U.S.D.A.

P6—Utilization of urea by calves less than four months of age. J. K. Loosli, C. M. McCay, and L. A. Maynard, Cornell University.

P7—The feeding value of Korean lespedeza seed as a protein supplement for milk production. H. A. Herman and A. C. Ragsdale, University of Missouri.

P8—The biological values of Korean lespedeza, alfalfa, corn, and milk proteins for growing dairy heifers. Eric W. Swanson, H. A. Herman, and A. C. Ragsdale, University of Missouri.

P9—A study of the nutritive value of some of the end-products of carbohydrate fermentation in the ensiling process. T. B. McManus and C. B. Bender, New Jersey Agricultural Experiment Station.

P10—Ruminal gases in normal and bloated animals. T. M. Olson, South Dakota Agricultural Experiment Station.

P11—The effect, on the butterfat percentage, of feeding moderate quantities of cod-liver oil. H. T. Converse and Rowland Trimble, Bureau of Dairy Industry, U.S.D.A.

P12—Further nutritional studies on calf scours. Norman S. Lundquist and Paul H. Phillips, University of Wisconsin.

1:30–3:30 P.M.—Lower Lounge, Abbot Hall

Vitamins and Reproduction

P13—Factors affecting the vitamin A and D potency of alfalfa hay. G. C. Wallis, South Dakota Agricultural Experiment Station.

P14—The vitamin A and carotene content of the blood plasma of calves from birth to four months of age. L. A. Moore, Maryland Agricultural Experiment Station.

P15—Vitamin C in dairy cattle nutrition. G. C. Wallis, South Dakota Agricultural Experiment Station.

P16—Carotene (provitamin A) requirements of dairy cattle for conception. A. H. Kuhlman and W. D. Gallup, Oklahoma A. and M. College.

P17—The relation of nutrition to breeding performance in dairy bulls. I. R. Jones, Oregon State College.

P18—Some preliminary results of feeding chloretone to bulls. E. C. Scheidenhelm, A. L. Bortree, C. F. Huffman, and C. F. Clark, Michigan State College.

P19—The effect of amphyl on bull sperm. H. O. Dunn, C. E. Shuart, and O. F. Garrett, New Jersey Agricultural Experiment Station.

P20—The relation of morphology to fertility in bull semen. G. W. Trimberger and H. P. Davis, University of Nebraska.

P21—Studies of respiration rate of dairy bull spermatozoa. Ray E. Ely, University of Missouri.

P22—The breeding efficiency of dairy bulls used both artificially and naturally. E. R. Berousek, University of Missouri.

P23—A comparison of artificial vs. natural service in heifers when bred to the same sire. C. E. Shuart, O. L. Lepard, and J. W. Bartlett, New Jersey Agricultural Experiment Station.

P24—Availability of carotene in alfalfa hay as compared with carotene in oil. J. H. Hilton, J. W. Wilbur, R. G. Westfall, and S. M. Hauge, Purdue University.

PRODUCTION SECTION—DIVISION B

Wednesday, June 24

9:00–11:00 A.M.—Grill, Abbot Hall

K. L. TURK, *Chairman*

Endocrinology and Milk Secretion

P25—The cause of the initiation of lactation at parturition. J. Meites and C. W. Turner, University of Missouri.

P26—Prehypophyseal hormone (Mammogen) control of mammary development. E. T. Gomez, Bureau of Dairy Industry, U.S.D.A.

P27—The effect of adrenalectomy on the lactogenic hermone and the initiation of lactation. J. J. Trentin and J. Meites, University of Missouri.

P28—The influence of thyroxin upon the stimulation of mammary lobule-alveolar growth. John P. Mixner, University of Missouri.

P29—The effect of thyroxin on rate of growth and efficiency of weight increment. Marvin Koger and C. W. Turner, University of Missouri.

P30—Growth and energy metabolism of thyroidectomized cattle. Samuel Brody, University of Missouri.

P31—The effect of thyrolactin on milk production, metabolism, and growth. E. P. Reineke, University of Missouri.

P32—The chemical formation of highly active thyroprotein. E. P. Reineke, University of Missouri.

P33—Methods of prolactin assay, including data on the prolactin content of the anterior lobe of beef and dairy cattle and female rabbits in several physiological conditions. S. R. Hall, Bureau of Dairy Industry, U.S.D.A.

P34—An intravenously active ovulating factor in the juice of corn and oat plants. J. T. Bradbury and R. E. Hodgson, Bureau of Dairy Industry, U.S.D.A.

P35—Further evidence of the existence and the physiological action of an orally active factor(s) in plant juices which affect the development of the sex organs of the rat. E. T. Gomez, Bureau of Dairy Industry, U.S.D.A.

P36—Some possibilities for the use of diethylstilbestrol in dairy cattle. Arthur A. Lewis, University of Missouri.

1:30–3:30 P.M.—Grill—Abbot Hall

Milk Secretion and Mastitis Control

P37—The influence of ascorbic acid on the gonadotropic content of the male rat pituitary gland. R. P. Reece and E. J. Weatherby, New Jersey Agricultural Experiment Station.

P38—Vitamin D, the parathyroid glands, and calcium metabolism. I. L. Campbell, University of Missouri.

P39—Oxygen uptake and CO_2 elimination of the bovine mammary gland. W. E. Petersen and J. C. Shaw, University of Minnesota.

P40—The utilization of lactic acid by dried bovine mammary gland tissue. Phillip L. Kelly, University of Arkansas.

P41—The effect of continued injection of pitocin upon milk and fat production. C. B. Knodt and W. E. Petersen, University of Minnesota.

P42—The incidence and control of milk fever. C. F. Monroe, W. E. Krauss, T. S. Sutton, and W. D. Pounden, Ohio Agricultural Experiment Station.

P43—The blood picture in normal and milk fever cows. W. E. Krauss, C. F. Monroe, R. G. Washburn, J. W. Hibbs, T. S. Sutton, and N. Van Demark, Ohio Agricultural Experiment Station.

P44—The nature of the material in mastitic milk responsible for the Whiteside reaction. H. O. Dunn, J. M. Murphy, and O. F. Garrett, New Jersey Agricultural Experiment Station.

P45—The value of tyrothricin (gramicidin) in a herd mastitis control pro-

gram. C. S. Bryan, Russell E. Horwood and C. F. Clark, Michigan State College.

P46—Experiences with lacto vaccine in the control of mastitis. C. F. Clark, C. S. Bryan, and Russell E. Horwood, Michigan State College.

P47*—Mastitis and herd practices in the college dairy herd. Russell E. Horwood, C. F. Clark, and C. S. Bryan, Michigan State College.

(*4:30–6:00 P.M. Demonstration of practices in mastitis control—Main Dairy Barn)

MANUFACTURING SECTION

Tuesday, June 23

1:30–4:00 P.M.—Lower Lounge, Mason Hall

O. F. GARRETT, *Chairman*

Symposium

Problems in Dairy Manufacturing Due to the War

A—The dairy industries position in W.P.B. Clyde Beardslee, Chief, Dairy Division, War Production Board.

B—The position of the dairy equipment manufacturers. Roberts Everett, Executive Secretary, Dairy Industries Supply Association.

C—The position of the public health service. A. W. Fuchs, Commander, U. S. Public Health Service.

D—Substitutes: types, kinds and application. G. W. Putnam, Vice President, Creamery Package Manufacturing Company.

E—Modifications in processing. P. H. Tracy, Department of Dairy Husbandry, University of Illinois.

4:00–6:00 P.M.—Room 211, Dairy Building
Judging Dairy Products (Milk)

Wednesday, June 24

9:00–11:00 A.M.—Lower Lounge, Mason Hall

L. H. BURGWALD, *Chairman*

Bacteriology—Chemistry

M1—The effect of acidity and temperature on the growth of *Oospora lactis* cultures. E. R. Garrison, University of Missouri.

M2—Various treatments which affect the growth of mold mycelia in cream and resultant butter. J. E. Edmondson and W. H. E. Reid, University of Missouri.

M3—The development of a positive phosphatase test on refrigerated pas-

teurized cream. F. W. Barber and W. C. Frazier, University of Wisconsin.

M4—The keeping quality of cream pasteurized at 165° F. for 30 minutes, variously treated, and stored at 0° F. E. S. Guthrie, Cornell University.

M5—The keeping quality of unsalted butter made from sweet cream pasteurized at 165° F. for thirty minutes and stored at 0° F. and 32° F. C. N. Stark, E. S. Guthrie and J. J. R. Campbell, Cornell University.

M6—Some observations concerning the ascorbic acid content of evaporated milk. D. V. Josephson and F. J. Doan, Pennsylvania State College.

M7—Control and verification of vitamin D in milk. M. J. Dorcas, National Carbon Company, Inc., Chicago.

M8—A voltammetric method for measuring the concentration of dissolved oxygen in dairy products. G. H. Hartman and O. F. Garrett, Rutgers University.

M9—Studies of the mechanisms of oxidized flavor. W. Carson Brown and F. C. Olsen, West Virginia University.

M10—Relation of dissolved oxygen to certain oxidation reactions in milk. G. H. Hartman and O. F. Garrett, Rutgers University.

M11—The role of the oxidase producing bacteria in the development of oxidized flavor in milk. J. Frank Cone and C. J. Babcock, Bureau of Dairy Industry, Washington.

M12—Bacteriological studies on creamery water supplies. R. T. Corley and B. W. Hammer, Iowa State College.

1:30–3:30 P.M. Lower Lounge, Mason Hall

W. H. E. REID, *Chairman*

Symposium

Problems in the Securing of Milk Quality

A—As accomplished by state programs,

California. O. A. Ghiggoile, Chief, Bureau of Dairy Service, California Department of Agriculture.

Wisconsin. L. G. Kuenning, Chief, Dairy Division, Wisconsin Department of Agriculture.

Tennessee. V. L. Fuqua, Dairy Commissioner, Tennessee Department of Agriculture.

B—As accomplished by cleaning methods,

Selection of detergents. L. H. Minor, J. B. Ford Company (Tentative).

Special methods and materials. L. Shere, Diversey Corporation.

3:30–4:30 P.M. Lower Lounge, Mason Hall

Business Session

4:30–6:00 P.M. Room 211, Dairy Building
Judging Dairy Products (Ice Cream)

Thursday, June 25

9:00–11:00 A.M.—Lower Lounge, Mason Hall
R. WHITAKER, *Chairman*

Dairy Products

M13—Sensory adaptation as a factor in the judging of dairy products for flavor. S. T. Coulter, University of Minnesota.

M14—A quick, colorimetric method for estimating the quality of butter. E. S. Guthrie and Georges Knaysi, Cornell University.

M15—The use of surface-active substances in the reconstruction of milk and cream. G. A. Richardson, University of California.

M16—Forewarming temperature of plain condensed skimmilk and properties of the resulting ice cream. Jack B. Clinch and J. H. Erb, Ohio State University.

M17—Relation of different mix compositions and methods of processing to the texture, structure and stability of ice cream. C. W. Decker and W. H. E. Reid, University of Missouri.

M18—The gases evolved by cheddar and limburger cheese. A. C. Dahlberg and F. L. Dorn, New York State Agricultural Experiment Station.

M19—The preparation of crystalline rennin. C. L. Hankinson, Carnation Company, Milwaukee, Wisconsin.

M20—The use of rennet paste in Romano-type cheese. C. A. Phillips, G. A. Richardson, and N. P. Tarassuk, University of California.

M21—Studies relating to the canning of pasteurized milk cheese. A. C. Dahlberg and J. C. Marquardt, New York State Agricultural Experiment Station.

M22—Comparative studies on cheddar cheese prepared with starter and with certain pure cultures. D. D. Deane and T. G. Anderson, Pennsylvania State College.

M23—General action in cheese of an enzyme preparation from chicken stomach. F. J. Babel, G. F. Stewart, and B. W. Hammer, Iowa State College.

11:00–12:00 A.M.—Lower Lounge, Mason Hall

Business Session

1:30–3:30 P.M. Lower Lounge, Abbot Hall
H. P. DAVIS, *Chairman*

Symposium

Curricula—Joint session with Production Section.

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ABSTRACTS OF LITERATURE

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American Butter Review
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American Journal of Diseases of Children
American Journal of Physiology
American Journal of Public Health
Archives of Pediatrics
Australian Journal of the Council for Scientific and Industrial Research

Biochemical Journal
Biochemische Zeitschrift

Canadian Dairy and Ice Cream Journal
Canadian Public Health Journal
Certified Milk
Cornell Veterinarian

Dairy Industries
Dairy World
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Endocrinology

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Journal of Agricultural Research
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Züchtungskunde

SPECIAL PUBLICATIONS

Federal Dairying and Bacteriological Establishment. Liebefeld, Berne, Switzerland

International Association of Ice Cream Manufacturers
International Association of Milk Dealers

National Institute for Research in Dairying, Reading, England
New York Association of Dairy and Milk Inspectors

Prussian Dairy Research Institute, Kiel, Germany

State Agricultural Colleges and Experiment Stations

The Royal Technical College, Copenhagen, Denmark

United States Department of Agriculture

ABSTRACTS OF LITERATURE

ADVANCE ABSTRACTS OF REPORTS ACCEPTED FOR PUBLICATION IN THE JOURNAL OF DAIRY SCIENCE

287. Carotene in Calf Nutrition. H. A. KEENER, S. I. BECHDEL, N. B. GUERRANT, AND W. T. S. THORP, Pa. State Col., State College, Pa.

Dairy calves of the Holstein and Guernsey breeds were raised to eight months of age on restricted levels of carotene intake. It was found that while the minimum carotene intake which would prevent vitamin A deficiency symptoms during warm weather was about 12 micrograms per pound of body weight per day, the requirement appeared to be about double this amount during cold weather. This observation was further substantiated by a relationship which existed between the environmental temperature and the vitamin A content of the blood. Histological changes were observed in the testicle, kidney, liver and intestines of calves which otherwise would have been considered as normal by the average dairyman. Calves receiving as much as 27 micrograms of carotene per pound of body weight per day were found to exhibit symptoms characteristic of vitamin A deficiency.

288. The Use of Ultraviolet Rays in the Cheese Factory and Storage Room. F. R. SMITH, Univ. Calif., Davis, Calif.

Attempts to control air-borne mold spores by means of 15-watt hot-cathode mercury-vapor lamps have not been effective. Direct exposure of cheese to the ultraviolet rays before and after paraffining failed to prevent mold growth. Data are given on the extent of penetration of ultraviolet rays through some common cheese-coating materials.

289. Blind Halves in a Goat's Udder. C. W. TURNER AND E. R. BEROUSEK, Department of Dairy Husbandry, Univ. Missouri, Columbia.

A case of a purebred Saanen goat is reported which failed to give milk after parturition. Upon anatomical study of the udder it was observed that milk was being secreted in the upper parts of the mammary gland but that the removal of the milk was prevented by the constriction (or blind ending) of the primary milk ducts leading into the cistern of the gland. Reasons are advanced for believing that this condition is due to an inherited or developmental defect in the glands rather than to the development of connective tissue overgrowth resulting from mastitic infection.

290. Factors Affecting the Passage of Liquids into the Rumen of the Dairy Calf. II. Elevation of the Head as Milk Is Consumed.

GEORGE H. WISE, G. W. ANDERSON, AND P. G. MILLER, S. C. Agr. Expt. Sta., Clemson, S. C.

The relation of the elevation of the head of the calf to the passage of ingested milk through the esophageal groove into the rumenoreticular cavity has been investigated anatomically and physiologically. The morphology and anatomy of the esophagus and the esophageal groove suggested that the opening and the closing of the lips of the groove are not regulated by mechanical positions and manipulations of the head and neck.

This was substantiated by observations of the physiology of the esophageal groove. Calves were fed from open pails and from nipple pails at floor level and at an elevation corresponding to the height of the withers. The position of the head at these two levels was not a significant factor affecting the frequency of spillage into the two fore compartments of the stomach, but the type of feeder played a very significant rôle. Irrespective of the feeder level, milk rarely entered the rumenoreticular cavity when consumed via nipple but frequently entered when drunk from an open pail.

Application of an electrical stimulus to a vagus nerve of anesthetized calves indicated that the vagi are paths through which certain stimuli may be transmitted to the esophageal groove and the rumen. The transmission and the resulting reaction of the groove were not affected by the position of the head and neck.

291. Studies on the Chemical Composition of the Blood of Dairy Cattle. III. The Normal Concentration of Inorganic Phosphorus in the Whole Blood of Dairy Cattle and Factors Affecting It. A. H. VANLANDINGHAM, H. O. HENDERSON, AND G. A. BOWLING, W. Va. Agr. Expt. Sta., Morgantown, W. Va.

Inorganic phosphorus was determined in more than 600 composite samples of whole blood taken from 59 heifers and cows in normal states of health and nutrition.

When growing dairy heifers were fed rations composed of good alfalfa or timothy hay and a concentrate mixture supplying liberal quantities of phosphorus, and such amounts of Vitamin D as occurred normally in the ration, age was the most important factor effecting the concentration of inorganic phosphorus in the blood.

The inorganic phosphorus in the blood of growing heifers increased with age up to about the seventh or eighth month after which there was a gradual decline as the animals grew older. The inorganic phosphorus in the blood of lactating cows decreased slightly up to about the third or fourth lactation.

Pregnancy caused a decrease in the inorganic phosphorus of the blood particularly during the last six to eight weeks preceding parturition.

There was no indication that the season of the year the heifers were born,

or the fact that they were confined to the barn continuously or permitted to run outside in favorable weather, had any effect upon the inorganic phosphorus content of the blood.

There was a strong tendency for cows beyond the first lactation to show a lower concentration of inorganic phosphorus in the blood during the winter and early spring months than during the summer and early fall.

292. Phospholipids in Dairy Products. I. Determination of Choline in Dairy Products. J. C. CRANE AND B. E. HORRALL, Department of Dairy Husbandry, Purdue University Agr. Expt. Sta., Lafayette, Indiana.

A number of experiments were made to determine the consistency of results obtained when extracted butterfat was subjected to relatively mild acid hydrolysis and the choline determined in the neutral of slightly acid hydrolysate by a method which was modified slightly from that of Roman. The values obtained were consistent under the proper conditions, although the choline periodide is unstable at temperatures much above the freezing point. It was further found that in agreement with other work, the factor which was recommended by Roman does not account for all the choline present in aqueous solutions. A corrected factor was used.

Tests made with hydrolysis procedure showed that aqueous normal hydrochloric acid was suitable as a hydrolyzing agent for the splitting of the choline from the lecithin in the extracted fat. A three to five gram sample, or more, was used.

Choline, which was added as freshly prepared egg phospholipids to butter oil, which was low in phospholipids, was recovered by the procedure used. The recovery of choline added as the chloride to butter oil, and to hydrolyzates from extracted milk fat was also carried out.

BOOK REVIEW

293. Dairy Engineering. ARTHUR W. FARRALL, Senior Research Engineer, The Creamery Package Manufacturing Co., Chicago, Ill. John Wiley & Sons, Inc., New York. $4.00.

Here is a book for which the dairy student has been looking for many years. It is written by one who has the point of view of the dairy engineering and dairy products instructor as well as the commercial operator. Mr. Farrall was formerly Assistant Professor of Dairy Engineering at the University of California and is now Senior Research Engineer for the Creamery Package Manufacturing Co.

Twenty-one chapters and an extensive and valuable appendix and many clear-cut illustrations complete the 405 pages of the book which should

serve as a splendid textbook for dairy manufacturing students of agricultural colleges. The first chapter of the book deals with such physical and chemical properties of milk as are of importance to the dairy engineer. Principles of mechanics, definitions, etc., make up the next chapter. In the following chapters, Power Transmission, Electrical Power and Equipment, Hydraulics and Pumping, Heat Measurements, etc., are covered in detail.

Steam and its use in the dairy, Boilers, etc., are amply covered, and a very complete chapter on Refrigeration follows. This chapter covers principles of refrigeration and various important aspects of dairy refrigeration are well handled.

Chapters include: Insulation, Heaters, Coolers and Heat exchange equipment, Ice Cream freezing equipment, including the various types of freezers, and the operation and factors affecting the same; Homogenization and Pasteurizing Equipment, Evaporating and Drying Equipment, Can Washing and Sterilizing Equipment. Also Bottle Washers, and Fillers, Cream and Butter Handling Equipment, Cheese and Casein Plant Equipment are covered. Equipment maintenance, Pipe Fittings, Fitting and Soldering, Dairy Plant Design, Layout and Utilization are covered in detail. A series of questions follow each chapter.

In the appendix of thirty pages is found a wealth of information useful to the engineer, production manager and student. C.D.D.

BACTERIOLOGY

294. Studies on Lactobacilli. III. Relationship of Immunological Specificity and Fermentative Capacity. R. W. HARRISON, Walter G. Zoller Memorial Dental Clinics and Dept. Bact. and Parasit., Univ. Chicago. Jour. Infect. Dis., *70*, No. 1: 69–76. Jan.–Feb., 1942.

Three hundred and three oral strains of lactobacilli were divided into two groups on the basis of their fermentative ability. Group A produced acid coagulation of milk and fermented sorbitol and mannitol with the production of acid. Group B failed to produce acid from sorbitol and mannitol, but produced acid without coagulation in milk.

Carbohydrate extracts from 75% of the Group A strains, when tested with Group A antiserum, precipitated type specifically. The group B strains, however, behaved as immunologically heterogeneous strains.

J.F.C.

295. Studies in Lactobacilli. IV. Changes in Immunological Specificity Associated with Changes in Fermentation Reactions. R. W. HARRISON, Walter G. Zoller Memorial Dental Clinics and Dept. Bact. and Parasit., Univ. Chicago. Jour. Infect. Dis., *70*, No. 1: 77–87. Jan.–Feb., 1942.

Changes in fermentative ability occurred with 26 oral strains of lactobacilli that were being carried on laboratory media. Carbohydrate extracts prepared from these strains after the fermentative changes occurred failed to precipitate with the specific antiserums prepared for the strains before the changes occurred. Antiserums prepared after the changes precipitated the new carbohydrate extracts, but failed to precipitate the carbohydrate extracts from the corresponding strains before the fermentative changes occurred. Similar but less clear-cut changes in immunological specificity occurred with 7 strains that did not show changes in fermentation reactions.

J.F.C.

296. **Reclamation of Agar.** HILDA G. MACMORINE, Connaught Labs., Univ. Toronto, Canada. Pub. Health Jour., *33,* 1: 39. 1942.

A method is described by which used agar can be freed of extraneous matter and reclaimed. About 75% of the agar used is recovered and when re-used in media gives a hardness only slightly inferior to fresh agar.

O.R.I.

297. **An Inexpensive Bacteriological Incubator.** C. S. BRYAN AND L. F. JENNINGS. Vet. Med., *36,* 11: 567–568. 1941. Abs. from Mich. Agr. Expt. Sta. Quart. Bul., *24,* 3. 1942.

Plans are presented for the construction of an efficient, inexpensive bacteriological incubator. The thermostatic control permits the regulation of temperature within the incubator from any point slightly above room temperature to 37° C. An inside temperature of 37° C, ± 2°, can be maintained under room temperature conditions varying from 1° to 39° C. This incubator is particularly well adapted to the incubation of milk samples for the microscopic test for streptococcic mastitis, but it can be used for other purposes also.

P.H.T.

BREEDING

298. **Studies of the Metabolism of Bovine Epididymal Spermatozoa.** GERTRUDE HENLE AND CHARLES A. ZITTLE, Dept. Bact., School of Med., Univ. Pa., Philadelphia. Amer. Jour. Physiol., *136,* No. 1: 70. Mar., 1942.

"Variations in the oxygen uptake of bovine epididymal spermatozoa, suspended in Ringer solution, were shown to be due (a) to differences in the individual samples; (b) to the concentration of spermatozoa, optimal respiration taking place in suspensions containing 400 to 800 million cells per ml.; (c) to the pH of the suspensions, highest oxygen consumption occurring at pH 7.5 to 8.0; (d) to possible differences in the degree of maturity of the cells.

"Oxygen consumption of bovine epididymal spermatozoa varied over a wide range. In analyzing this phenomenon it was observed that spermatozoa derived from individual epididymides showed different oxygen needs. Spermatozoa undergo a process of maturation while passing through the epididymis. On frequent emission the cells become more and more immature, while on the other hand spermatozoa stored for a long period in the epididymis lose gradually their fertilizing capacity. These physiological changes may account for some of the individual differences found in this study in that spermatozoa of varying degrees of maturity may have different metabolic requirements. Although the various developmental stages could not be tested, results obtained with seminal and epididymal spermatozoa showed that the oxygen uptake was so much lower in the former that there is no doubt that respiration is less in seminal cells." D.E.

299. Some Endocrine Relationships in Nutritional Reproductive Failure. H. R. GUILBERT, Univ. Calif. Jour. Anim. Sci., *1*, No. 1: 3. Feb., 1942.

This is a review of the effect on reproduction, and some possible reactions on endocrine activity, of inanition; of deficiencies of protein and fatty acids; of vitamins A, E, and B (complex); and of the minerals Ca, P, I, and Mn. The author recommends that animal husbandmen give more attention to recording reproductive failures occurring within the borders of their respective states. G.C.W.

BUTTER

300. The Surface and Center of Storage Butter. W. MOHR AND E. SCHRIMPL. Molk. Ztg. (Hildesheim), *53:* 1212–1214. 1939.

Water- and air-impermeable paper preserved the surface of storage butter. Surface samples always scored lower in flavor than center samples. There was no correlation of this with chemical differences.

Butter stored for 180 days at – 4° F. kept well later at 60° F. for 2 weeks after being thawed at the same temperature. J.C.M.

301. Change Aroma of Butter During Storage. W. MOHR, E. SCHRIMPL, AND A. ARBES. Molk. Ztg. (Hildesheim), *53:* 1501–1503. 1939.

The authors report small quantities of biacetyl in sweet cream butter when churned and after storage. Sour cream butter when made has a significant in flavor percentage of biacetyl, which may remain constant or decrease upon storage. Iron and copper are associated with off-flavors in butter. J.C.M.

302. Butter Quality Forecasts. F. X. MAIER AND F. KIERMEIER. Molk. Ztg. (Hildesheim), *53:* 856–861. 1939.

Butter held at 35° C. was scored daily for three months. The yeast and bacteria count after 2 weeks was an index to the quality production. The aldehyde test was used to indicate the yeast count.

The authors concluded that yeasts and bacteria directly and indirectly affected the quality change to a lower grade in 32 and 27%, respectively, of the cases. Metals and oxidation reduced grades in 22% of the samples. The remaining 19% of the samples remained unchanged; and the count after 2 weeks plus the aldehyde determination indicated that in these cases there should be no reduction in quality. J.C.M.

303. Studies on Surface Taint Butter. I. Odor Production by Pseudomonas putrefaciens. H. WOLOCHOW, H. R. THORNTON, Univ. of Alberta, AND E. G. HOOD, Dominion Dept. Agr., Ottawa. Sci. Agr., *22,* 5: 277. 1942.

Ps. putrefaciens inoculated into sterile skimmilk (10% spray powder in water) produced a typical "sweaty feet" odor. Butter produced from similarly treated cream showed surface taint defect only when subjected to certain conditions. The evidence suggests that "a precursor is formed in minute amounts in the milk serum under the influence of high temperatures. This precursor appears to follow the casein fraction, . . . *Ps. putrefaciens* appears to act on this precursor to produce the immediate precursor which may then undergo a chemical change, presumably involving oxidation, to form the 'sweaty feet' and surface taint substance."

Neutral or slightly acid conditions, and high heat treatment were necessary for the "sweaty feet" odor to develop in the skimmilk or S. T. to develop in the butter. In alkaline skimmilk, the odor was putrid. Raw cream and cream pasteurized by the vacreation process did not result in S. T. butter. S. T. production was partially or completely inhibited by the addition of Avenex No. 3, hydroquinone and diacetyl, and Cu changed the odor to one resembling brown sugar. Freshly cut cubes of S. T. butter did not develop the defect when held in an atmosphere freed of O_2.

Heavier salting and more complete working operated to prevent or delay the appearance of the defect. O.R.I.

304. Studies on Surface Taint Butter. II. An Odorous Compound in Skimmilk Cultures of Pseudomonas putrefaciens. W. L. DUNKLEY, G. HUNTER, H. R. THORNTON, Univ. of Alberta, AND E. G. HOOD, Dominion Dept. Agr., Ottawa. Sci. Agr., *22,* 6: 347. 1942.

Cultures of *Ps. putrefaciens* and *B. subtilis* were grown separately in 10% reconstituted, spray-dried skimmilk for two weeks. *Ps. putrefaciens*

gave a "sweaty feet" odor. Steam distillates from both cultures were obtained, concentrated and subjected to Duclaux analyses for volatile fatty acids. Steam distillate residues obtained from both cultures contained formic, acetic, butyric and isovaleric acids. Throughout the analyses the "sweaty feet" odor followed the isovaleric acid fraction. It is concluded that the substance causing "sweaty feet" odor in skimmilk cultures of *Ps. putrefaciens* is closely related chemically to isovaleric acid. O.R.I.

CHEESE

305. Cheese Factory Sanitation. P. RITTER. Schweiz. Milch Ztg., *65*, 26: 135–137. 1939.

The author recommends the reductase test for the receiving platform. Mastitis tests with indicator paper are recommended for regular barn inspections.

The author also favors typing the cheese vat milk for each bath. The pH and propionic acid bacteria should be determined in a cheese sample 24 hours old.

Details for following curd strength, whey acidity and like matters are described. J.C.M.

306. Brine for Cheese Making. G. SCHWARZ AND B. BEINERT. Molk. Ztg. (Hildesheim), *54:* 77–78. 1940.

The authors report that brine baths for salting cheese by the immersion method should have a salt content of 18 to 22%. Likewise the acidity should range from .34 to .40 determined with a 9 gram sample of brine following the common test for "acidity" in milk. Weakly acid, neutral or slightly alkali brine solutions are objectionable because of the flora which they favor. J.C.M.

307. Studies on Film-Forming Yeasts. II. Film-Forming Yeasts in Rennet Brine. V. E. GRAHAM AND E. G. HASTINGS, Univ. Saskatchewan and Univ. Wis. Canad. Jour. Res., *20,* 2, Sec. C: 63. 1942.

In the commercial production of rennet extract, calves' stomachs are soaked in brine tanks held at low temperature. Unless special precautions are taken, a heavy scum forms on these tanks. Salt-tolerant yeasts of the genus *Debaryomyces* which grow well at low temperatures are chiefly responsible for this scum from which *D. tyrocola,* originally isolated from cheese, and *D. Guilliermondi,* originally isolated from sausages, were isolated. Attempts to isolate these species from the contents of a calf's stomach,

salted calves' stomachs, dried calves' stomachs and soil were unsuccessful. These species did not grow in a medium containing 20% sodium chloride, nor in one in which the pH had been lowered to 2.0. O.R.I.

CHEMISTRY

308. Determination of Total and Inorganic Bromide in Foods Fumigated with Methyl Bromide. S. A. SHRADER, A. W. BESHGETOOR AND V. A. STENGER, Dow Chemical Co., Midland, Mich. Jour. Ind. Eng. Chem., Analyt. Ed., *14,* No. 1: 1. 1942.

A method is proposed whereby methyl bromide is removed under conditions which lead to minimum decomposition and it is determined as the difference between total bromide and inorganic bromide. Application to several different types of food products including American cheese indicates that no methyl bromide remains as such for more than four days after fumigation. B.H.W.

309. Colorimetric Determination of Phosphorus in Biological Materials. RUTH ADELE KOENIG AND C. R. JOHNSON, Texas Univ., Austin, Texas. Jour. Ind. Eng. Chem., Analyt. Ed., *14,* No. 2: 155. 1942.

Misson's spectrophotometric method for the estimation of phosphorus has been improved for use in biological materials by increasing its range, sensitivity and precision. A description of the improved method, its applications and a summary of typical results in various materials including milk powder are presented. B.H.W.

310. Determination of Citric Acid in Pure Solutions and in Milk by the Pentabromoacetone Method. EDGAR F. DEYSHER AND GEORGE E. HOLM, U. S. Dept. Agr., Bur. Dairy Ind., Washington, D. C. Jour. Ind. Eng. Chem., Analyt. Ed., *14,* No. 1: 4. 1942.

"The determination of pentabromoacetone formed by the action of potassium permanganate and bromine upon citric acid under controlled conditions has been used as a basis for the quantitative determination of citric acid by various authors. The recovery of citric acid by the methods employed has usually been less than the theoretical value, especially where sugars have been present." Losses may be incurred through incomplete conversion of citric acid to pentabromoacetone, by volatility of the precipitate or by its solubility in the reaction mixture and wash water. A study of losses was made and suggestions are advanced for aiding in a more complete recovery of citric acid as pentabromoacetone. "The modified method applied to aliquote of solutions containing from 0.10 to 0.30 gram of citric acid gave results that were consistently within $\pm$ 0.50% of the theoretical values.

When the quantity of citric acid was less than 0.10 gram the percentage recoveries were slightly less than the value given and the results were not so consistent as those obtained with the use of larger amounts. In the case of milk the quantity of serum that can be conveniently used in each determination is such that the approximate amount of citric acid present is less than 0.10 gram. The results obtained upon decitrated milks to which citric acid in these amounts had been added were usually within ± 1.00% of the theoretical values, though the differences between duplicate determinations were usually greater than those in which larger amounts were present."

B.H.W.

CONCENTRATED AND DRY MILK; BY-PRODUCTS

311. Production of Textile Casein. F. RICHTER. Milk. Ztg. (Hildesheim), *53:* 1163–1168. 1939.

Sulphuric acid-precipitated casein is desired for textile use. The whey obtained from this method is rendered suitable for stock feed by adding 1½ pounds of an equal mixture of calcium carbonate and calcium hydroxide per 1000 pounds of whey. J.C.M.

312. Production and Consumption of Manufactured Dairy Products. E. E. VIAL, U. S. Dept. Agr., Tech. Bul. 722.

This publication discusses briefly the historical aspects of production trends of the different manufactured products starting with the year 1849. The per capita consumption of all manufactured dairy products (milk equivalent) rose from 305 pounds in 1870 to 421 pounds in the period 1930–1937. The upward trend prior to 1900 was due primarily to the increasing per capita consumption of butter, and since then to the upward trend in the consumption of cheese, concentrated milks and ice cream. Domestic consumption has increased somewhat more rapidly than domestic production.

In the past 85 years the long-term tendency has been for butterfat prices to rise in relation to prices of feed grains, which has been an important factor in causing farmers to expand dairying in relation to some other types of agricultural production. P.H.T.

DISEASE

313. Persistence of Antibodies One Year After Active Immunization of Human Beings with a Mixed Heat-Killed Vaccine of *B. typhosus, Br. abortus* and *Br. melitensis.* JOHN A. KOLMER, AMADEO BONDI, JR., AND ANNA M. RULE, Res. Inst. Cutan. Med. and Dept. Bact. and Immunol., Temple Univ. School of Med., Philadelphia. Jour. Infect. Dis., *70,* No. 1: 54–57. Jan.–Feb., 1942.

Tests were made with the serums of 29 normal human adults that had been immunized one year previously with a mixed heat-killed vaccine of *Bacillus typhosus, Brucella abortus* and *Brucella melitensis.* The tests made were for H and O typhoid agglutinins, *Br. abortus* agglutinins, *Br. abortus* opsonins, and serum protection tests in mice with all three organisms.

With few exceptions there was a decrease in serum potency of all of the immunized individuals as compared to tests that had been made two weeks following immunization. However, with all tests a high percentage of the serums (56 to 100%) showed potency levels still higher than the pre-immunization levels. J.F.C.

314. Calf Scours. C. F. CLARK, East Lansing, Mich. Mich. Agr. Expt. Sta. Quart. Bul., *24,* No. 2: 99–100.

Specific remedies for the treatment of both white and dietary scours are given. Emphasis is placed upon prevention, however. The preventive measures recommended for both types of the disease are as follows: 1. Provide a clean, dry, well-bedded maternity stall in which the cow may calve. It is wise to clean and disinfect the maternity stall after each cow has calved there. It is presumed that the cow has been properly fed so that there will be adequate vitamin A in the milk on freshening. 2. Disinfect the navel of the calf with tincture of iodine as soon after birth as practicable. 3. Make certain that the calf receives colostral milk as early as possible, by assisting it to nurse if necessary. Check to be certain that some milk is obtained from each quarter of the udder. 4. Do not allow the calf to consume an overload of colostrum. The present-day high-producing dairy cow produces more milk than even the most vigorous calf can successfully consume. If the calf is to be pail-fed it may learn to drink more readily if removed from the cow soon after active bowel function is established. 5. Continue the feeding of dam's milk for a week after birth. 6. Begin pail feeding by giving milk amounting to 6–8 per cent of the body weight per day. Feed at regular hours and intervals, in clean pails, at a temperature of 98–100° F. Weak calves may do better if fed three times daily. 7. Keep the calf pens well bedded and dry. Elevated floors, of heavy, expanded metal, are excellent. Single pens are to be preferred. If several calves must be kept together, it may be well to tie them after feeding milk so as to discourage sucking. 8. If scouring or other disease appears in calves, consult the best qualified veterinarian possible to employ. P.H.T.

FEEDS AND FEEDING

315. Management Practices and Returns on White Clover Pastures. E. VANDER MEULEN, G. MCINTYRE, AND C. M. HARRISON, East Lansing, Mich. Mich. Agr. Expt. Sta. Quart. Bul., *24,* 3: 233–238. 1942.

The white clover has largely disappeared from pasture land in Michigan due to mismanagement and lowered soil fertility. Areas in which white clover can be re-established are generally confined to the cool, moist regions located in the northeastern portion of the lower peninsula, and in the upper peninsula. The plant is most productive on the heavier soils which are low-lying or have characteristics of poor drainage.

Top-dressings of phosphatic fertilizers coupled with a close grazing by livestock are essential to the maintenance of the plant. P.H.T.

316. Legume Silage vs. Corn Silage vs. Legume Hay for Fattening Heifer Calves. G. A. BRANAMAN AND G. K. DAVIS, East Lansing, Mich. Mich. Agr. Expt. Sta. Quart. Bul., *24,* 3: 227–232. 1942.

The object of this experiment was twofold: (1) to compare alfalfa hay and alfalfa silage when equal amounts of corn are fed, and (2) to determine the amount of corn required with alfalfa hay or alfalfa silage to equal well-eared corn silage. Texas-bred Hereford heifer calves of "good" grade were used in this test. The alfalfa hay and silage were made from first-cutting alfalfa containing a heavy timothy mixture. For the ensilage 40 pounds of beet molasses was mixed with each ton of alfalfa. The cattle ate the silage more readily than they did the hay, and their gains in weight were more consistent. The grass silage must be supplemented with grain in order to make it comparable to corn silage. Under the conditions of the experiment one pound or more of corn was added for each 100 pounds of body weight. Calves fed corn silage gave a higher return per head above feed cost and a higher value per ton of silage than those fed alfalfa silage. The hay-fed cattle graded lowest and the alfalfa silage-fed cattle highest in carcass grade. The corn silage-fed cattle graded highest in color of fat, while the alfalfa silage-fed cattle graded lowest. P.H.T.

317. Carotene in Feed Grasses. JOHN ALLARDYCE AND DOUGLAS MILSOM, Univ. Brit. Columbia, Vancouver. Canad. Jour. Res., *20,* 2, Sec. C: 85. 1942.

Cuttings of feed grasses less than 7 inches high were found to vary considerably on carotene content. Factors that were found to contribute to these variations were: (1) the amount of sunshine and rain prior to cutting, (2) the height of the cutting, and (3) the manner of storage. Higher carotene content was found when the cuttings were taken following periods of increased daily sunshine. Cuttings less than 7 inches high contained larger amounts of carotene than did 12 inch cuttings. Storage of the ground, dehydrated feed grasses at 35° F. for three months reduced the carotene content by 7.5%. O.R.I.

318. Seasonal Changes in the Lignin and Cellulose Content of Some Montana Grasses. A. R. PATTEN AND LEONARD GIESEKER, Mont. Agr. Exp. Sta., Bozeman. Jour. Anim. Sci., *1*, No. 1: 22. Feb., 1942.

Lignin and cellulose were determined in 5 species of grass, at 5 stages, in 2 localities. The species included 3 wheat grasses and 2 brome grasses, and the stages ranged from the first evidence of flower stalks to shattered seed heads. In the first stage the lignin content was slightly over 5 per cent and the cellulose content was slightly over 20 per cent in all cases. In the last stage the lignin content had increased about threefold and the cellulose less than twofold. In the more arid area the grasses reached the maximum lignin content earlier. As lignin is practically indigestible this gives further evidence that more attention should be given this substance in forage analyses. G.C.W.

319. The Metabolism of Calcium and Phosphorus as Influenced by Various Activated Sterols. E. W. MCCHESNEY AND FREDERICK MESSER, Res. Labs., Winthrop Chemical Co., Rensselaer, N. Y. Amer. Jour. Physiol. *135*, No. 3: 577–586. Feb., 1942.

The effects of single massive doses of vitamin D_2, D_3 and of Ertron (a form of irradiated ergosterol) and A.T. 10 (dihydrotachysterol) on the calcium and phosphorus metabolism of dogs have been compared. As to serum calcium, vitamin D_2 and Ertron are essentially the same in their effects. Vitamin D_3 is characterized by the long persistence of a rather moderate degree of hypercalcemia. "A.T. 10 causes a very rapid rise of serum calcium followed by a comparatively rapid fall. All the products cause a rise in serum phosphorus (Ertron not studied). All of the products decrease fecal and increase urinary output of calcium. They also increase fecal output of P and either increase urinary output or maintain it at a constant level in spite of decreased intake. All of the products except vitamin D_3 improved calcium balances; Ertron improved the phosphorus balance slightly." D.E.

FOOD VALUE OF DAIRY PRODUCTS

320. Fats and Oils. ELIZABETH F. WHITEMAN AND FLORENCE B. KING, U. S. Dept. of Agr., Leaflet 204. 1940.

This article, prepared primarily for the housewife, contains useful information regarding the energy value, vitamin value, and digestibility of the various fats and oils commonly used in the household (butter, oleomargarine, lard, hydrogenated fats and compounds, and salad oils). Explanation is also given of the use and care of these various oils and fats. P.H.T.

321. Is There Need for the Fortification of Milk? E. V. McCollum, Johns Hopkins Univ., School of Hygiene and Public Health, Baltimore, Md. Amer. Jour. Pub. Health, *32*, No. 1: 80–84. 1941.

The conclusion is made that it is unwise to permit fortification of milk other than with Vitamin D. It is unnecessary in the interest of the consumer and undesirable from the standpoint of the distributor. There is no advantage in making any single food a complete food for all nutritional purposes. We will fare best by taking a variety of foods, each of which provides something which is needed. M.W.Y.

ICE CREAM

322. Sweeteners Used in Ice Cream. B. E. Horrall, Purdue Univ. Agr. Expt. Sta., Lafayette, Ind. Ice Cream Field, *34*, 2: 28. 1942.

The author gives in concise form the generally accepted recommendations regarding the use of sweetening agents that can replace part of the sucrose in ice cream. He refers to the work of various investigators which shows that corn sugar, invert sugar, honey, certain corn syrups and dried corn syrups can be used up to 25% of the total sugar without sacrifice of body and texture in the finished ice cream. W.C.C.

MILK

323. Milk for the Family. Rowena S. Carpenter, U. S. Dept. Agr., Farmers Bulletin 1705. 1940. (This bulletin supersedes Farmers Bulletin 1359, issued 1933.)

This publication of 29 pages is a popular treatment of milk from the standpoint of its use in the home. An explanation of the products manufactured from milk is also given. The nutritive value of milk is discussed, the pasteurization process is explained, and the different commercial grades of milk are defined. Directions for the proper care of milk in the home are given and a brief discussion of the use of milk in cooking is presented. P.H.T.

324. Sour Cream—How to Prepare and Use It in the Home. U. S. Dept. Agr., Leaflet 213. 1941.

Methods for making sour cream suitable for home operations are presented. Twenty different recipes for the use of sour cream are given. This material would be useful for encouraging milk customers to make more extensive use of sour cream as sold by milk plants. P.H.T.

325. E. O. D. Delivery—The Ruination of the Small Dealer. W. E. DONOHUE, David Donohue & Sons, Holyoke, Mass. Milk Dealer, *31,* 5: 56–58. Feb., 1942.

The author points out that the every-other-day delivery plan suggested to relieve the tire situation is the brain child of the milk trusts; that small dealers and milk plant owners haven't a chance of surviving against such a scheme; that they would lose a good part of their volume and patronage to the stores, as many of the multiple quart customers will not sacrifice space in their refrigerators to hold two days' milk supply. This drop in volume would put the small dealers out of business to the benefit of the large dealers with wholesale store routes. It is suggested that the six-day delivery plan should be adopted and in cases where it is possible, to have two dealers combine their routes, using one truck one day and the other the following day. C.J.B.

326. "Do's and Don'ts" in Handling Cream. L. R. GLAZIER, Dairy Engineer, The Pfaudler Co. Milk Dealer, *31,* No. 5: 94. Feb., 1942.

A convenient tabulation of the causes and methods of preventing the following cream defects is given: 1. Cream plug. 2. Feathering. 3. Foaming. 4. High acidity. 5. Lipase (enzyme) activation. 6. Off-flavors. 7. Oiling off. 8. Poor whipping ability. 9. Poor viscosity. 10. Serum separation. C.J.B.

327. A Method of Determining Fat in Homogenized Milk. J. C. MARQUARDT, N. Y. Agr. Expt. Sta., Geneva, N. Y. Milk Dealer, *31,* No. 5: 24. Feb., 1942.

The author presents a modification of the Babcock fat test which gives clear fat columns with homogenized milk. The modification consisted in adding the acid in three equal charges, shaking well after each addition. Following the first centrifuging the samples were removed and thoroughly shaken. This was repeated after half of the first addition of water was made, and again after the completion of the water addition prior to the second centrifuging. After the second run the samples were again shaken before the final addition of water. C.J.B.

328. The Place of Ice Milk in the Dairy Industry. HARRY B. BURT, Pres., Malt-A-Plenty, Inc., Tulsa, Okla. Ice Cream Field, *34,* No. 2: 24, 32, 33. 1942.

The greatest development of ice milk has occurred in California, where the manufacturer and the public have cooperated to regulate and produce a nutritious, healthful product. Ice milk is defined as "a wholesome dairy product, frozen in the same manner as ice cream but with a butterfat content approximating that of whole milk."

Little difficulty with ice milk has been encountered in localities where its production is governed by law or regulation; manufacturers, however, in

localities where regulations do not exist often experience considerable difficulty. It is claimed that low-income groups, unable to purchase ice cream, can afford ice milk. This accounts for its greater success in the southern states.

The author claims that ice milk has a greater digestibility than high-fat ice cream. (Abstractor's note: No specific evidence is given to substantiate this claim.)

It is stated that ice milk is not a substitute for ice cream, but that it should be given recognition and be regulated along with ice cream. It is advocated that those in the industry should strive to gain a Federal Standard for ice milk. W.C.C.

329. **Metallic Flavored Milk.** H. HERZFELD AND E. VOLLBRECHT. Deut. Molkerei-Ztg., *60:* 635–671. 1939.

Copper and iron rods were used to stir pasteurized milk for two minutes to demonstrate metal effects upon flavor. Both procedures gave comparable metallic flavors when the stirring was at 176° F. However, decreasing the time factor proved that copper was far more harmful than iron. The authors failed to associate intensity of the off-flavors with quality of the raw milk. J.C.M.

330. **Separating Sour Cream Buttermilk.** W. MOHR, A. ARBES, AND M. KELTING. Molk. Ztg. (Hildesheim), *53:* 2153–2155. 1939.

It is possible according to the authors to separate sour cream buttermilk in a foamless separator. The separating is best achieved at 60° F. with the adjustments made for a 20% cream. The yield of 20% cream is about 15 pounds per 1000 pounds of sour cream buttermilk. This results from a sour cream buttermilk containing .45% of fat. The yield is greatly increased when the buttermilk contains, as is sometimes the case, more than 1% of fat. The cream obtained is equal in physical and general character to normal cream. J.C.M.

331. **Studies on the Antioxygenic Effect of Oat Flour Treated Milk Bottles for Milk Exposed to Sunlight.** C. W. ENGLAND AND ARTHUR P. WIEDEMER, Md. Agr. Expt. Sta., College Park, Md. Milk Dealer, *31,* No. 3: 33–36. Dec., 1941.

Report of a study to determine the value of oat flour in preventing sunlight-induced oxidized flavors in market milk. The following conclusions are drawn: 1. Increasing the length of time milk is exposed to sunlight increases the intensity of the oxidized flavor. 2. Midday sunlight induces more intense oxidized flavors in milk in glass bottles than morning and afternoon sunlight; while morning sunlight induces more intense oxidized flavors in milk

in paper bottles than midday and afternoon sunlight. 3. The exposure of milk at 70° F. to sunlight results in increased oxidized flavor development compared to milk exposed at 40° F. 4. Paper bottles offer more protection to milk from sunlight oxidation than glass bottles. 5. Paper bottles treated with oat flour when exposed to sunlight for 10 minutes or less afford little protection to the development of sunlight-induced flavors in milk as compared with plain paper bottles. 6. Oat flour treated paper bottles offer some protection to milk against oxidized flavors when the period of exposure to sunlight exceeds 10 minutes. C.J.B.

Editor's comments: The oxidized flavor described should not be confused with the tallowy or oxidized flavor induced by copper contamination. The "sunshine" flavor is in reality an effect of the light rays upon the milk protein.

332. This Milk Distribution Problem. EDWARD THOM, Assoc. Ed., The Milk Dealer. Milk Dealer, *31,* No. 3: 22–23, 48–50. Dec., 1941.

The milk distribution problem is discussed mainly from the standpoint of six-day delivery. The advantages of six-day delivery are summed up as follows: 1. Puts the regular route man in full control of his route, which results in more uniform and accurate service at all times. 2. Driver salesmen like it because they always know they will have Sundays to themselves. 3. Makes it possible to cut cost of distribution. 4. Makes the job of delivery more desirable and makes it possible to obtain better men more easily. 5. From a public relations standpoint, it is considered more valuable than seven-day delivery. 6. Relieves the management of the greater part of Sunday responsibilities. 7. Customers become accustomed to quantity purchases, which apparently results in the greater consumption of milk.

C.J.B.

333. Factors Affecting the Sale of Milk. DR. L. D. H. WELD, Dir. Res., McCann-Erickson, Inc. Milk Dealer, *31,* No. 4: 74–86. Jan., 1942.

Such factors as Package Cost, Price Spread, Increasing Consumption, Vitamin Appeal, Increased Buying Power, Consumer Attitude, etc., are discussed in their relation to the sale of milk. The following promotion suggestions are offered:

1. Stress the importance of adequate daily amounts of milk. Consumers over-estimate the amounts consumed and they must be made definitely conscious of the quantity that they drink and the quantity that they ought to drink. 2. Direct the campaign largely to adults. Adults form two-thirds of the population and only half of them drink milk now. 3. Direct the campaign to both men and women. The deficiency is nearly equal between men

and women. 4. Feature milk drinking by showing how its nutritional value is greater than that of other beverages. 5. Play up the use of milk between meals and at bed-time. 6. Meet the taste factor squarely. When milk is played up as a part of appetizing meals or with other foods, a real appetite appeal for it can be developed. 7. Stress the economy of milk. Show that as compared with other foods milk is cheap. 8. Tie in your general nutrition story with the government program. 9. Use strong emotional appeals to urge action. People have a high regard for the value of milk and this proves that the educational work that you have done has been effective. You will get the market ready and keep it ready through additional effort spent in advertising. C.J.B.

334. Milk Service for Factories. ANONYMOUS. Milk Dealer, *31*, No. 4: 30–31, 46–47. Jan., 1942.

The milk service for factories based mainly on the experience at the Thermoid plant in Trenton, New Jersey, where the plan to serve a half-pint of milk daily was inaugurated in April, 1941, is discussed. Since the plan was inaugurated it is estimated that the plant has had: 1. A 30% reduction in accidents, with an improvement in safety. 2. Fewer absences due to illness, indicating a general improvement in employees' health. 3. An increase in production during those hours that were formerly low points in the employees' day. Since practically all workers are on a piece-work basis, their incomes have increased. C.J.B.

335. Accidents Don't Happen. ROBERT I. GAYLEY, Safety Director, Supplee-Wills-Jones Milk Co., Philadelphia, Pa. Milk Dealer, *31*, No. 4: 22–23. Jan., 1942.

A description is given of how the Supplee-Wills-Jones Milk Co. is attacking the problem of safe driving from a new angle. Actual driving contests, including such operations as backing, holding a line, blind and sight side-parking, and turning in a restricted area, are conducted. According to the author there are two main problems which any safety director of a large company must face. First he must try to eliminate the causes of accidents before they occur. Second, he must overcome the smugness of the average driver who believes he has nothing to learn about the safe operation of a vehicle. C.J.B.

336. Streamlining Our Milk Delivery System. ROICE ANDERSON AND LELAND SPENCER, Cornell Univ., Ithaca, N. Y. Milk Dealer, *31*, No. 5: 22–24, 48–54. Feb., 1942.

A discussion is given of methods to conserve tires and reduce other expenses. The discussion is summarized as follows:

The most promising change in the system of milk deliveries from the point of view of tire conservation and cost saving is the adoption of alternate-day delivery. The indications are that savings of from 20 to 35% can be made in this way. By introducing an appropriate schedule of discounts for volume deliveries to consumers, any distributor can proceed with alternate-day delivery whether or not the plan is adopted by his competitors. Even where the alternate-day system is not adopted, a considerable saving in delivery time, though not in truck mileage, can be accomplished by the use of volume discounts or the use of larger-than-quart-size containers to encourage customers to take their milk on alternate days.

Smaller but considerable savings can be made in other ways:

(1) By discounting or exchanging customers who are expensive to serve, such as customers at a distance from main route, single or scattered stops in apartment houses, and split stops at stores, restaurants, etc. (2) By drastically curtailing call-backs and special deliveries. (3) By changing from early-morning to daylight delivery.

Providing the proper steps are taken to explain the need for such changes, and providing appropriate discounts are offered in recognition of the lesser cost of more limited service, it is more than likely that consumers will respond favorably.

A change from the competitive system of milk delivery to a unified or monopoly system would be much more difficult to accomplish than any of the other changes suggested. The limited experience with milk distribution under public or private monopoly gives little basis for judging the probable results from the standpoint of efficiency. Any plan of unification so far conceived would involve not only a consolidation of delivery service, but the elimination of private brands as well. It seems unlikely that much progress toward unification will be made except as a war measure, by direct order of the national government. C.J.B.

337. Ramblings on Vending. Roy K. Quinlan, Quinlan & Baker, Providence, R. I. Milk Dealer, *31,* No. 2: 42–46. Nov., 1941.

The author discusses milk vending from the standpoint of causes for failure. The most frequent causes of failure are: Not enough attention to where the machine is located, incompetent salesmen, and poor servicing. C.J.B.

338. Stability of the Fat Emulsion of Homogenized Milk. F. J. Doan, D. V. Josephson, and James Adams, Pa. Agr. Expt. Sta., State College, Pa. Milk Dealer, *31,* No. 2: 35, 54–60. Nov., 1941.

Report of a study to determine whether or not the requirement for homogenized milk as defined by the U. S. Public Health Service milk ordi-

nance and code is too stringent. This ordinance defines homogenized milk as follows:

"Homogenized milk is milk which has been treated in such a manner as to insure break-up of the fat globules to such an extent that after 48 hours' storage no visible cream separation occurs on the milk and the fat percentage of the top 100 cc. of milk in a quart bottle, or of proportionate volumes in containers of other sizes, does not differ by more than five per cent of itself from the fat percentage of the remaining milk as determined after thorough mixing."

The following conclusions are drawn: 1. Much of the commercial homogenized milk sold fails to meet the requirements for the product stipulated by the U. S. Public Health Service definition. 2. A method of removing the top 100 ml. of homogenized milk from a quart bottle for the purpose of determining whether it conforms to the United States Public Health Service definition is described. 3. By this method analyses of duplicate bottles check very closely, even though it is visually evident that some fat is not removed in the upper 100 ml. from unstable samples of milk. 4. A modification of the Babcock test is described for homogenized milk. This test checks as closely as can reasonably be expected with the Mojonnier method and United States Public Health Service Indices of fat stability calculated from modified Babcock tests and from Mojonnier tests agree very closely, indicating that the Babcock method is satisfactory for the purpose. 5. The fat content of homogenized milk (between 3.5 and 4.5%) has only a very small and inconsistent effect on the stability of the fat emulsion. 6. The rotary homogenizer used in the study is more efficient in stabilizing the fat emulsion of homogenized milk than the piston machines used, when similar pressures are employed. 7. Piston homogenizers, of the types used, must be operated at pressures exceeding 3,000 pounds to consistently produce milk meeting United States Public Health Service requirements. The rotary and centrifugal homogenizers used cannot satisfactorily meet this definition. 8. An extremely close relationship exists between the United States Public Health Service Index and the Farrall Index of efficiency of homogenization. A Farrall Index of approximately 20 corresponds with a United States Public Health Service "per cent difference" of five. 9. The United States Public Health Service definition of homogenized milk is unreasonably stringent.

C.J.B.

339. The Influence of the Time and Temperature of Homogenization on Certain Properties of Milk. G. M. TROUT AND M. V. SCHEID, East Lansing, Mich. Mich. Agr. Expt. Sta. Quart. Bul., *24*, No. 2: 122–131.

Raw milk was held at 40° F. for 24 hours before homogenizing at 5000 pounds pressure at 40°, 60°, 100°, 120° and 140° F. Complete dispersion

of the fat did not occur until a temperature of 100° F. was reached. Marked increases in acidity resulted when the raw milk was homogenized at 80°, 100° and 120° F. At 60° and 140° the increases were slight and at 40° F. there was no change in acidity.

When milk homogenized raw at 130° F. was immediately pasteurized, no harmful flavor effects were noted. Raw milk vigorously agitated at 40° F. failed to develop an increased acidity or a rancid flavor.

When milk is to be homogenized before pasteurization it must be preheated high enough to inactivate the lipase or the plant facilities must provide for immediate pasteurization after homogenization. P.H.T.

340. Foaming of Homogenized Milk. G. M. TROUT AND M. V. SCHEID, East Lansing, Mich. Mich. Agr. Expt. Sta. Quart. Bul. *24*, No. 2: 113–115.

Raw milk homogenized at 100° F. and then pasteurized showed less foaming than that homogenized after pasteurizing. Slightly less foaming occurred when the milk was homogenized after pasteurization if the temperature was lowered to 100° F. before homogenization took place. The foaming of homogenized milk can be best controlled by exercising caution in operation such as: 1. Operating the bottles at slow speed. 2. Maintaining a maximum head of milk in the supply tank. 3. Reducing splashing of milk at cooler spreader pipe to minimum. 4. Reducing drop from cooler coils to the cooler reservoir. 5. Having air-tight connections in the lines.

P.H.T.

341. Overcoming Seepage of Bottled Homogenized Milk. G. M. TROUT, East Lansing, Mich. Mich. Agr. Expt. Sta. Quart. Bul., *24*, 3: 217–227. 1942.

To overcome seepage of bottled homogenized milk due to expansion of the milk it is recommended that the filler valves be adjusted so that 56-mm. bottles will not be filled closer than one-fourth inch from the cap seat. Such may not be the case with the 48-mm. bottle, however, which when filled to the bottom of the lip roll must be kept from warming appreciably if seepage is to be overcome.

Bottles of homogenized milk should be handled in such a manner during distribution as to keep the milk out of contact with the cap as much as possible. The increased capillarity and penetrability of milk due to homogenization coupled with an expansion of the milk may result in seepage if the milk is allowed to contact the closure seat regularly. P.H.T.

PHYSIOLOGY

342. Effect of the Gonadotropic Substance of Pregnant Mare's Serum on the Blood Plasma-Ascorbic Acid of the Bovine. RALPH E. ERB AND FREDERICK N. ANDREWS, Purdue Univ. Endocrinology, *30*, No. 2: 258. Feb., 1942.

Two bulls and 4 cows were injected subcutaneously with amounts of gonadotropic hormone (Gonadin) varying from 1000 to 2250 rat units during 8 individual trials. In certain of these experiments crystalline vitamin C was administered subcutaneously in sterile saline solution. The gonadotropic hormone caused a decrease in venous blood plasma-ascorbic acid (42 to 67%) of the two bulls during the first 24-hour period. The hormone treatment caused decreases of 20 to 50% during the first 24-hour period in the 4 cows. The recovery of blood plasma-ascorbic acid to approximately pre-injection levels required 8 to 10 days in the cow and longer in the bull unless extraneous vitamin C was injected. R.P.R.

343. The Effect of Thyroidectomy on Lactation in the Albino Rat. DAVID KARNOFSKY, Stanford Univ. Endocrinology, *30*, No. 2: 234. Feb., 1942.

Virgin albino rats weighing 200 gm. and about 140 days old were thyroidectomized before conception, during gestation, or immediately after delivery. All litters were reduced to 5 but frequently death of the young further reduced this number. The young were weighed daily and the weights used as an indication of milk production. The results indicated that: (1) the thyroid gland does not appear to be essential for lactation in the rat; (2) thyroidectomy immediately after delivery, during gestation, or before conception causes a decrease in milk production; (3) thyroidectomy before conception or during pregnancy does not inhibit mammary gland development; and (4) thyroid replacement in thyroidectomized rats probably increased milk production. R.P.R.

344. Changes in the Fat Percentage and Fat Yield of Dairy Cows with Injections of an Anterior Pituitary Preparation. J. F. SYKES, W. L. MEULEMAN, AND C. F. HUFFMAN, Mich. State Col. Endocrinology, *30*, No. 2: 217. Feb., 1942.

Four cows, 3 Holsteins and one Jersey, in declining lactation were used for experimentation. Milk fat percentage was determined on 3-day composite milk samples. A fat metabolism preparation of the anterior pituitary was injected for 5-day periods in 500-mg. amounts. For comparative purposes a prolactin preparation was injected in 500-mg. amounts into the same 4 cows during another 5-day period. The fat metabolism preparation

caused a marked increase in the fat production in 3 of the 4 injected cows and slight increases in milk volume in each cow. The prolactin injections caused similar increases in milk volume but had no detectable effect on milk fat percentage. R.P.R.

345. The Influence of Ascorbic Acid on the Activity of Gonadotropic Hormones. ALFREDO V. DI CIO AND MARIO SCHTEINGART, Clinic of Dr. Mariano R. Castex. Endocrinology, *30,* No. 2: 263. Feb., 1942.

The simultaneous injection of 25 rat units of gonadotropic hormone and 50 mg. of ascorbic acid daily for 20 to 30 days into 2- to 4-month-old rats produced a greater increase in development of testis and penis, and of female genitalia than the hormone alone. The testicular weight was almost doubled by the combined treatment as compared with the hormone alone. Ascorbic acid alone produced no increase in the weight of the testes. There appeared to be no effect from injecting the vitamin into adult animals or over a 3-day period. R.P.R.

346. Initiation of Lactation in Nulliparous Heifers by Diethylstilboestrol. S. J. FOLLEY, H. M. SCOTT WATSON (MRS. C. C. THIEL), AND A. C. BOTTOMLEY, Nat. Inst. for Res. in Dairying, Reading. Jour. Physiol., Proc., *100,* No. 3: 7–8. Nov., 1941.

The application of five grams of diethylstilboestrol dipropionate ointment three times weekly to the udders of two nulliparous Dairy Short-horn heifers ($18\frac{1}{2}$ and 20 months of age) resulted in a maximum secretion of 170 ml. of fluid daily. "The composition of the secretion varied somewhat at different periods of the experiment but never resembled that of normal milk, since it always contained less casein and more globulin. At times the fat content approached normal but the non-fatty solids were usually deficient." D.E.

347. Copper-Induced Pseudopregnancy in the Adult Estrous Rat. A. DURRY AND J. T. BRADBURY, U. S. Dept. Agr., Div. Nutr. and Physiol., Bur. Dairy Ind. Amer. Jour. Physiol., *135,* No. 3: 587–590. Feb., 1942.

"Intravenous administration of copper solutions induce pseudopregnancy in the adult estrous rat. The minimal effective dose is 0.1 cc. (0.3 mgm. of copper ion) of a 1% copper acetate solution. Approximately 1 cc. of the same solution is the minimal ovulating dose in the estrous rabbit. These data suggest that copper may act through the pituitary. They also suggest that a fundamentally similar neuroendocrine physiology exists in

both spontaneously ovulating rat and the non-spontaneously ovulating rabbit."

The Bureau of Dairy Industry also reported on the gonad-stimulating materials in plants in the Report of Chief of the Bureau of Dairy Industry, 1941, p. 30. These two reports have many points of common interest.

D.E.

MISCELLANEOUS

348. Proper Lubrication—A War Time Defense Job. EDWARD THOM, Assoc. Ed., The Milk Dealer. Milk Dealer, *31,* No. 5 : 31–34, 42–44. Feb., 1942.

A discussion is presented of the necessity for proper lubrication and how it can be best accomplished. A follow-up file is suggested in order to be certain that all moving parts are lubricated at the proper time. The use of the proper lubricant, depending on type and size of machine, speeds, temperatures, and surrounding conditions with respect to moisture, dust, etc., is stressed. The lubrication of bottle washers, refrigerator equipment, conveyors, etc., is then discussed. C.J.B.

349. Adjustable Wage Scale Based on Changing Cost of Living Adopted by Louisville Dealers. ANONYMOUS. Milk Dealer, *31,* No. 3 : 68–70. Dec., 1941.

A brief description of the automatic wage-adjustment plan used by Louisville dealers-employees is presented. Hourly wage rates under this plan are based on the commodity price index. A table showing the changes in hourly wages with changes in the commodity index is given. C.J.B.

350. Paraffin Wax. EDGAR F. WRIGHT, Mono Service Co., Newark, N. J. Milk Dealer, *31,* No. 4 : 28–29, 50. Jan., 1942.

A discussion of the use of paraffin wax in the dairy industry and its war uses is given. With a view to helping the O.P.M. and the dairy industry in conserving paraffin wax the following suggestions are offered : 1. Do not use waxed sheet paper or waxed containers where the time period is short or where unwaxed paper may otherwise be used. 2. Ask for and test out any available alternatives or substitutes, both to relieve the demand and to prepare for the possible necessity for substitution. 3. Use a lighter waxing where it can be satisfactorily used. 4. Where a thick coating of wax is used merely for its decorative merchandising value—sacrifice this for "the duration." This has already been done in the case of cellophane which is permitted as a wrapper in contact with a food, but cannot be used as an outer decorative wrapper for the same food. C.J.B

351. Stokers. ANONYMOUS. Milk Dealer, *31*, No. 4: 24–25, 42. Jan., 1942.

A discussion is given of how stokers offer a solution to many plant problems. It is pointed out that evidence collected from users indicates beyond a doubt that boiler capacity can be stepped up considerably when a stoker replaces hand firing. In addition many other problems are eliminated, such as smoke nuisance, high fuel costs, shortage of manpower, and unsanitary boiler rooms that are a source of plant contamination. C.J.B.

352. Large-Scale Organization in the Dairy Industry. R. K. FROKER, A. W. COLEBANE, AND A. C. HOFFMAN, U. S. Dept. Agr., Cir. 527. 1939.

Since the close of the first World War there has been a marked development of large-scale corporations in all branches of dairy manufactures. Though there are several producer marketing cooperatives operating on a national scale, in general large-scale developments under the cooperative form of business enterprise have not been so rapid as those under the corporate form. During the period of 1925 to 1930 the total sales of all dairy products increased 12% while the total sales of the four leading dairy companies (National Dairy Products Corp., Beatrice Creamery Co., The Borden Co., and the Fairmont Creamery Co.) increased nearly 300%. In 1934 the largest dairy corporation handled milk products equivalent to 9.4% of the total volume of milk moving into commercial channels. Growth of the large companies has been accomplished mainly through the purchase and consolidation of many small plants.

Meat packers and grocery chains are important handlers of dairy products. Many of the latter now own or control their own assembling and processing plants.

The cooperatives have shown little or no expansion in their scale of operations since 1930.

Capital investment in the four leading dairy companies earned from 16 to 18% in the six-year period 1925–30, 4.9% in 1932 and 9.2% in 1937. Profit margins ranged from as high as 7.3% in 1928 to as low as 3.2% in 1934.

The large companies control a larger percentage of the evaporated milk industry than they do butter and cheese. Concentration of control in distribution is greater than in the field of manufacture. Eleven dairy companies control about 18% of the total volume of fluid milk consumed in villages and cities in the United States. Three companies alone distribute 16%. In large cities the three largest dairies often control 60–90% of the total volume of market milk sold.

The use of the motor-truck in assembling milk from farms, better utiliza-

tion of by-products, and increased efficiency have been important factors in the growth of large dairy companies.

The distribution of butter shows less centralization than any other product. About 50% of the evaporated milk is made by three companies: Carnation, Pet, and Whitehouse (A & P).

The growth of mass distribution has resulted in a decrease in the importance of the middleman (the commission merchant, and broker, and the produce jobber).

Large-scale organization has not been extended to dairy-farming operations to any considerable degree.

There has been an increase in the unionization of labor employed in the manufacture and distribution of dairy products. This change has occurred largely in the large plants. Since unionization of labor usually means higher labor cost this factor may retard further consolidation and integration in the industry.

Patent rights constitute important instruments of economic control in the dairy industry. Outstanding examples have been the basic patents on process cheese and commercial uses of casein.

The part that cooperative marketing can play in a system of mass distribution is questionable but it seems that manufacturing and local assembling of the product are clearly within their province. The most satisfactory arrangement between the cooperative and the mass distributor is one under which their functional set-ups complement rather than duplicate each other.

P.H.T.

The Third Annual Meeting of the Institute of Food Technologists is to be held at the University Farms, St. Paul, Minn., June 15 to 17, 1942, the week previous to the American Dairy Science Association meeting in East Lansing, Michigan.

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The American Dairy Science Association was organized to advance the general welfare of the dairy industry, especially by the improvement of dairy instruction by the stimulation of scientific research in all phases of the subject and by improvement in methods of conducting extension work.

Membership. Any person is eligible to membership who is formally announced by an Agricultural College or Experiment Station, or by the Bureau of Dairy Industry of the United States Department of Agriculture or by the Canadian Department of Agriculture as an instructor, extension worker, investigator, or administrative officer connected with the dairy industry, or any person filling a position of responsibility connected with the dairy industry who has had a college or university training in technical science, or any person filling a responsible position in the dairy industry of a professional character requiring a technical knowledge of dairying of a high order. The membership fee is $5.00.

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