Variation in Milk Constituents

small variations in milk composition may require processing modifications or result in products of inferior market quality

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The composition of milk changes during a year due to stage of lactation of the cows primarily, and to feed and weather conditions and those changes may cause difficulties in dairy product manufacture.

Milk is a complex biological fluid containing many substances. Some of those substances—such as certain salts, some vitamins, and the milk sugar—are in true solution as ions or molecules and are primarily responsible for such properties of the milk as boiling point, freezing point, and the diffusion of the constituents, the osmotic pressure. Other substances in the milk—such as proteins and certain milk salts—have larger particle size and are not truly dissolved in the water; they are dispersed colloidally—in particles—and influence the milk-body, as well as other properties of milk and dairy products. The fat is dispersed as rather large droplets to form an emulsion and is important to many properties of milk. The quantity of fat may vary a great deal.

During the past several years biweekly samples of milk from processing plants in the principal producing areas of California—Fernbridge, Petaluma, Willows, Davis, Newman, and Visalia—have been analyzed for any changes that might occur in the manufacturing milk supply. The biweekly samples are fractionated into several component parts and the parts are analyzed for protein, phosphorus, citric acid, calcium, and magnesium, each of which influences milk behavior during processing.

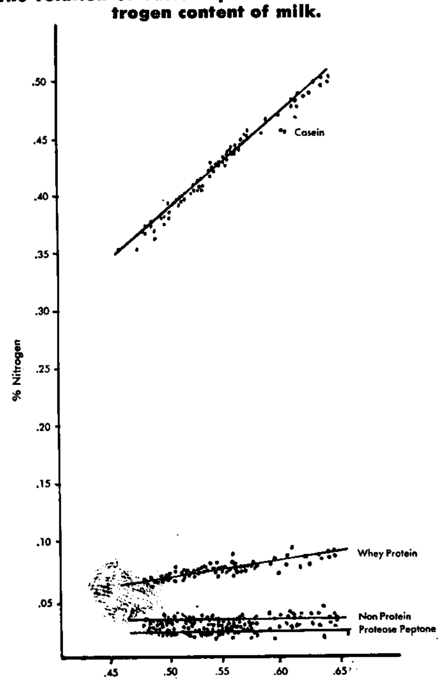
The proteins of milk are important to the chemical and physical properties of dairy foods. Nitrogen is the element characteristic of proteins and the total nitrogen is distributed among the casein, the whey proteins, the proteose-peptone—a protein fraction precipitated with salts but not with heat or acid—and the non-protein nitrogen—soluble nitrogen compounds such as amino acids, ammonia, and so forth. Each of the fractions is composed of a mixture of several individual proteins.

The total nitrogen content showed a variation—in the biweekly analyses—from a minimum of 10% in the Willows milk to a maximum of nearly 18% in the Fernbridge milk. The difference in nitrogen levels in milks from the different areas is due primarily to the breeds of cows found there. Holstein milk, for example, has a lower nitrogen—protein—content than milk from Jerseys or Guernseys.

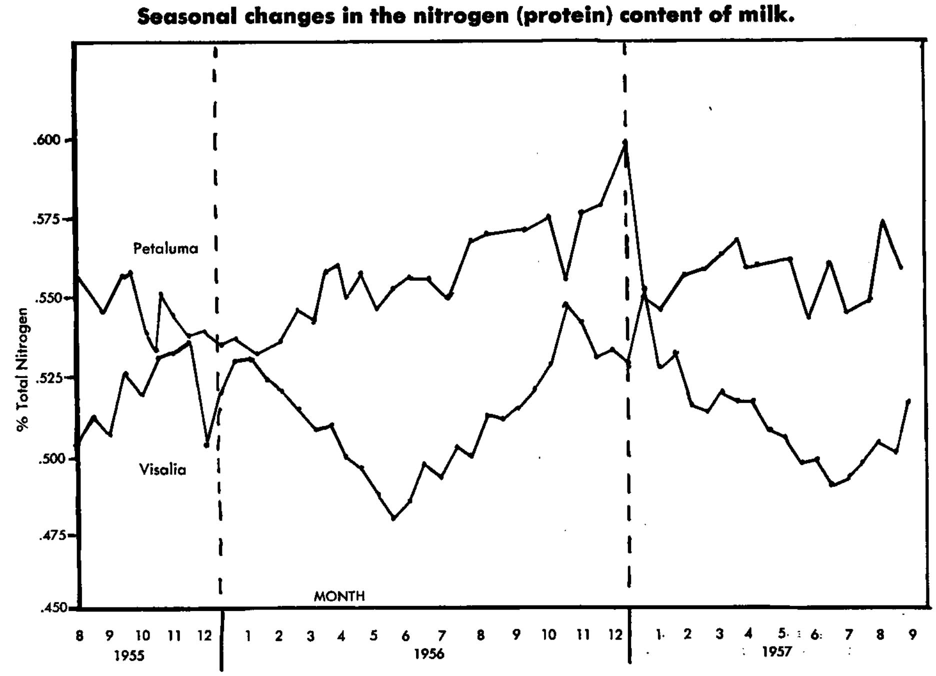
The protein content—total nitrogen—is highest during the winter, decreases during the spring and summer, and increases again in the fall. Casein fluctuates to about the same relative extent as the total nitrogen. Casein is high when total nitrogen is high and low when total nitrogen is low. The whey proteins also fluctuate in this same pattern, but do not show as close a correlation to changes in total nitrogen as does casein. When there is a change in total nitrogen content of milk, it results in a change in quantity of several milk proteins and not in one protein alone. The proteose-peptone and non-protein fractions are very small in quantity and are independent of the total nitrogen content. In fact these fractions remain nearly constant throughout the year.

Changes in the quantity of protein will definitely affect the acceptability of the milk as a beverage because milk of low protein content may appear thin in body. The same changes will affect also certain physical properties of the milk and yields in the manufacture of cheese, milk powder, or other concentrated milk products.

The relation of various proteins to the total nitrogen content of milk.



Seasonal changes in the nitrogen (protein) content of milk.



Phosphorus

The phosphorus in milk is not present as a single compound, but is present in many forms. It is part of the casein molecule; it forms organic compounds with other constituents; and it is present as inorganic colloidal phosphates as well as phosphate ions in solution.

The total phosphorus in milk showed a variation of 16%–19% in the different areas. The variation is seasonal, tending to be high in the winter or spring and low in the summer. Although the fluctuations in phosphorus do not coincide exactly with variations in protein, phosphorus—as a rule—does tend to increase or decrease in conjunction with changes in protein content.

The average soluble inorganic phosphorus was rather uniform—approximately 335 parts per million—in the milk from the different areas. This is a measure of the phosphates in solution, which are important to protein stability. The colloidal phosphates are associated with the proteins as complexes, such as calcium phosphate-calcium caseinate complex, and the seasonal variations in this fraction and in casein are similar.

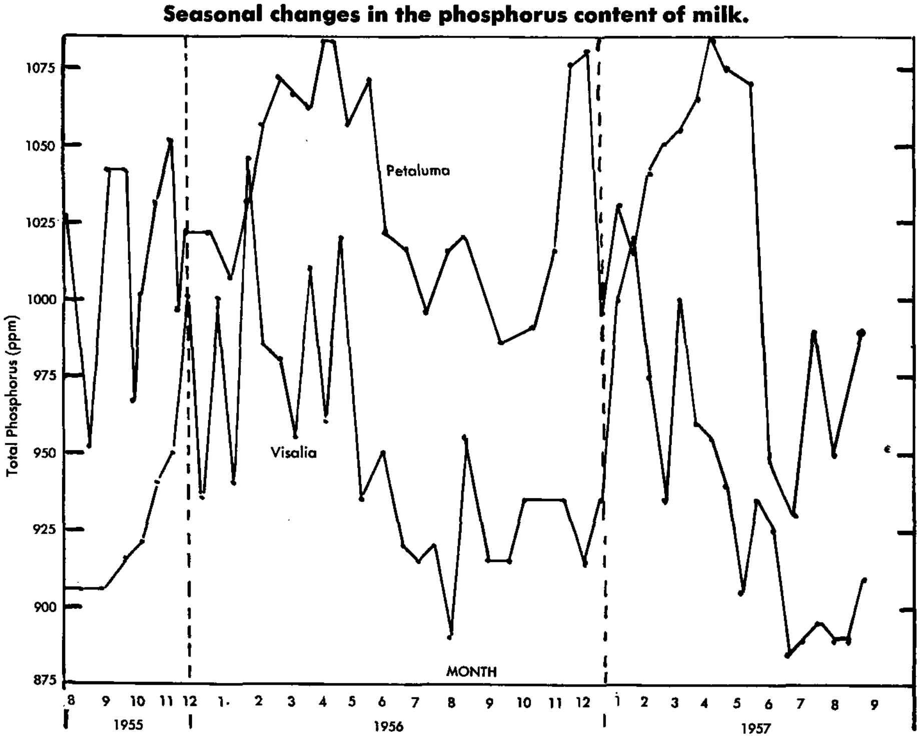
Monthly Averages of Calcium and Magnesium in California Milk (grams per liter)

Milk plant	Month 1	2	3	4	5	6	7	8	9	10	11	12	Average
Visalia	1.46	1.54	1.61	1.71	1.43	1.40	1.40	1.40	1.38	1.37	1.46	1.45	1.47
Newman	1.51	1.45	1.46	1.57	1.54	1.51	No data	1.36	1.41	1.38	1.47	1.44	1.46
Davis	1.44	1.33	1.51	1.54	1.47	1.59	1.41	1.55	1.45	1.41	1.45	1.41	1.46
Willows	1.48	1.56	1.58	1.53	No data	1.54	No data	1.46	1.47	1.46	1.52	1.47	1.51
Petaluma	1.57	1.60	1.67	1.64	1.48	1.60	1.58	1.54	1.49	1.51	1.56	1.56	1.57
Fernbridge	1.61	1.68	No data	No data	1.63	1.59	No data	1.56	1.54	1.60	1.59	1.73	1.61

Monthly Averages of the Citrates in California Milk (as % Citric Acid)

Milk plant	Month 1	2	3	4	5	6	7	8	9	10	11	12	Average
Visalia	0.156	0.150	0.153	0.172	0.150	0.150	0.117	..	0.159	0.137	0.132	0.130	0.146
Newman	.166	.182	.153	.145	..	.143	.121	.137	.136	.147	.156	.142	.148
Davis	.135	.166	.150	.162	.116	.123	.119	..	.119	.141	.146	.130	.137
Willows	.162	.168	.166	.160	.138	.152	.116	..	..	.173	.148	.141	.152
Petaluma	.179	.186	.188	.163	.168	.144	.120	.124	..	.154	.145	.127	.154
Fernbridge	.147	.134	..	..	.157	.148	.135	.162	.148	.126	.121	.134	.141

Seasonal changes in the phosphorus content of milk.



Calcium and Magnesium

Calcium and magnesium are important to curd formation in cheesemaking, to heat stability of milk, to stability of frozen concentrated milk, and to certain properties of ice cream mix. The total calcium plus magnesium showed 13%–21% variation and calcium alone a 9%–16% variation during the year in all areas. Milk that had the lowest average protein content also had the lowest calcium plus magnesium—1.35–1.57 grams per liter—and milk with the highest average protein had the highest calcium plus magnesium—1.52–1.77 grams per liter. This was true also for calcium alone. The average magnesium content —0.15–0.16 grams per liter—was the same for all areas. These mineral salts showed season variations, but the high was in the spring in some areas and in the late fall or winter in other areas. Calcium and magnesium do not necessarily fluctuate together. For example, calcium in most areas tends to be high in the fall and low in the summer; magnesium tends to be high in the spring and low in the fall.

Citrates

The citrates of milk showed a greater variation during the year than any other constituent. Milk from the processing plant at Newman had the least variation with 56% and that from the plant at Fernbridge the most with 98%. Although there is considerable variability from month to month, there are definite seasonal trends. The highest levels are usually found in February, March, or April, depending on area. The lowest levels are found during the hot summer months of June, July, or August. This is followed by higher citrate levels in September or October and lower levels again in November or December. It would not be possible to explain these variations in citrate by differences in feed alone. Other seasonal variations, such as temperature, must be involved.

The milk constituents studied—the casein, whey proteins, the various phosphorus fractions, calcium and magnesium, and citrates—fluctuate to some degree depending upon season. All show at least a 10% variation and some vary a great deal more than this. Although the proteins vary in quantity, the relative proportions of one to the other remain fairly constant. The calcium and calcium plus magnesium vary in about the same relative quantities as the proteins. The phosphates show larger fluctuations, but in the same direction as changes in the quantity of protein. The citrates on the other hand fluctuate widely and not in relation to changes in the protein or any

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MILK

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other constituent studied. The citrate ions combine with calcium ions to form a soluble calcium citrate thus reducing the calcium ion activity in milk. The calcium ion activity is important in acid and rennet coagulation, heat stability of milk, possibly gelation of evaporated milk, stability of frozen concentrated milk, and to certain properties of ice cream mix. Citrate fluctuations may well be the key to seasonal changes in milk properties.

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The milk samples used in these studies were furnished by the cooperation of Alta California Dairies, Inc., Willows; Golden Valley Creamery Co., Newman; Humboldt Creamery Association, Fernbridge; Knudsen Creamery Co., Visalia; Petaluma Cooperative Creamery, Petaluma; and University Creamery, Davis.

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PRUNE

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The 1957 season was the sixth year in one orchard, and the fourth in another where the shaken ripe fruit was picked up from the ground by machines. A successful picking job was done in both cases, although average total tonnage per machine did not come up to expectations. Heavy rains before completion of the harvest reduced the tonnage that would have been picked by machine. Even with less than full capacity use, total harvesting cost was less with machine than with hand picking.

Effective—and economical—machine harvesting requires better management than other methods. The size of the orchard and the dehydrator capacity must be sufficient to justify at least daily half-time use of the machine and other equipment during the harvesting season. Removal of limb props at first picking is no great handicap but trees without propping would be desirable. Good land preparation—by some type of drag or plane and roller—is essential because the orchard soil must be free of surface clods and stones. Fruit is picked up from the ground by mechanical means and dumped—with some clods and leaves—into a tub of water on a trailer behind the harvester. Filled tubs are hauled by fork lift to the dehydrator where the washer-separator is located. This method is limited to farms with dehydrators.

There has been no evidence in Napa and Sonoma counties that the quality of the final product of the French variety picked by machine differs from that of prunes picked by hand.

The table on this page shows in detail the investment and harvesting costs with machines under an assumed set of conditions for 40 acres and 200 tons of fresh prunes, which is near the low limit of size for which this method is suited. A machine under average yield and good conditions could probably pick 60 acres with a total yield averaging 300 tons of fresh fruit, but varying from 200 to 500 in different years.

The performance rate of a picking machine varies greatly with the yield because the machine picks about an acre an hour. Hence, in any picking, it could pick from one tub or ton an hour up to six if the haul were sufficiently short to permit a fork lift to replace the tubs fast enough. Maximum use over the years will seldom be attained because of occasional unfavorable soil or weather conditions, distance to the dehydrator, or dehydrator capacity.

When using the machine for the first picking, three crew members keep a few rows ahead of the machine; two men shaking and one raking the prunes out of the tree row with the small engine-driven side rake and from around the trunks by hand with a spring-tine lawn rake. In the second or last picking where the trees are cleaned, four men hand shaking, or two men pneumatic shaking, may be needed. For a season average, sample costs shown in the table assume four men hand shaking and raking nine hours daily, which would probably be ample, even for a heavier yield.

In machine-picking, the harvesting includes delivering the prunes and dumping them into a washer-separator at the dehydrator. From there, they are mechanically moved to the tray loader. In both cases observed, the fork lift had a tilting device enabling the operator to tilt the tub and pour the prunes and water into the washer. No lug boxes are needed and part of the saving in this method is in transportation. The fork lift—having many other uses, particularly with lift bins at the dehydrator—is charged in the sample harvesting costs, shown on the table below, at one half its cost.

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Sample Investment and Total Harvesting Costs for Three Methods
Assumed: A 40-acre orchard, 200 fresh tons, 20-day season, 2 pickings

	Hand		Frames		Machine	
	Quantity	Cost	Quantity	Cost	Quantity	Cost
INVESTMENT						
Shaking poles @ $8.00	6	$ 48	4	$ 32	4	$ 32
Buckets @ $1.00	12	12	2	2		
Lug boxes @ $1.00	600	600	600	600		
Catching frames @ $450.00			2	900		
Picking machine					1	2700
Side rake with engine					1	400
Trailer for tubs					1	250
Tubs @ $40.00					4	160
Fork lift $1200, ½ to picking						600
Washer						600
Miscellaneous small and shop tools		20		40		200
Total original cost		$680		$1574		$4942
ANNUAL OVERHEAD COSTS						
Interest on ½ cost @ 5%		$ 17		$ 39		$124
Depreciation		70		230		496
Repairs, mounting, etc.		18		40		125
Total annual overhead		$105		$309		$745
COSTS PER TON						
Average annual overhead		$ 0.53		$1.53		$3.73
Extra ground preparation @ $5.00 per acre						1.00
Shaking and sweeping @ $1.00					3.6 hr.	3.60
Shaking and picking @ 30¢, 25¢	36 bx.	10.80	36 bx.	9.00		
Picking machine operator @ $1.50					.5 hr.	.75
Supervision, loading, driving truck or fork lift @ $1.25	1.4 hr.	1.75	.9 hr.	1.13	.5 hr.	.63
Tractor for machine @ $1.50					.5 hr.	.75
Truck @ at $2.50 per hour	.5 hr.	1.25	.5 hr.	1.25		
Fuel, etc, for sweeper, fork lift						.30
Total cost per ton		$14.35		$12.91		$10.76