Dairy Byproducts

by EARLE O. WHITTIER

WHENEVER more milk is produced than is needed to supply the demand there arises the problem of disposal of the surplus. One solution is to increase consumption by urging greater use of milk, a slow method, or reducing prices, not always a feasible method. The problem usually is partly solved by converting the surplus milk into relatively nonperishable products like butter, whole-milk cheese, evaporated and sweetened condensed whole milk, and dried whole milk—products that can be easily stored or transported to places that need them.

The greatest money value of whole milk is in the milk fat, so primary emphasis is put on products containing all or most of the fat. Its value, though, makes it impractical to consider the use of milk fat for nonfood purposes; many cheaper fats are available and suitable for such uses. It is generally true that use in food is the most gainful way to utilize all the components of milk.

The production of butter and cheese from surplus milk leaves, as byproducts, skim milk, buttermilk, and whey, which also are byproducts in the making of cream, butter, ice cream, and cheese from nonsurplus milk. The problem of disposal of surplus milk includes, therefore, not only the primary one relating to the milk fat and foods containing milk fat, but also finding use for the practically fat-free byproducts.

The problems of disposition of surpluses and byproducts of the dairy industry are not new. They were becoming increasingly acute in the years before the war. During the war there were other problems—insufficiency of food and feed—but they are gradually disappearing again, and the utilization of surpluses and byproducts requires increased attention.

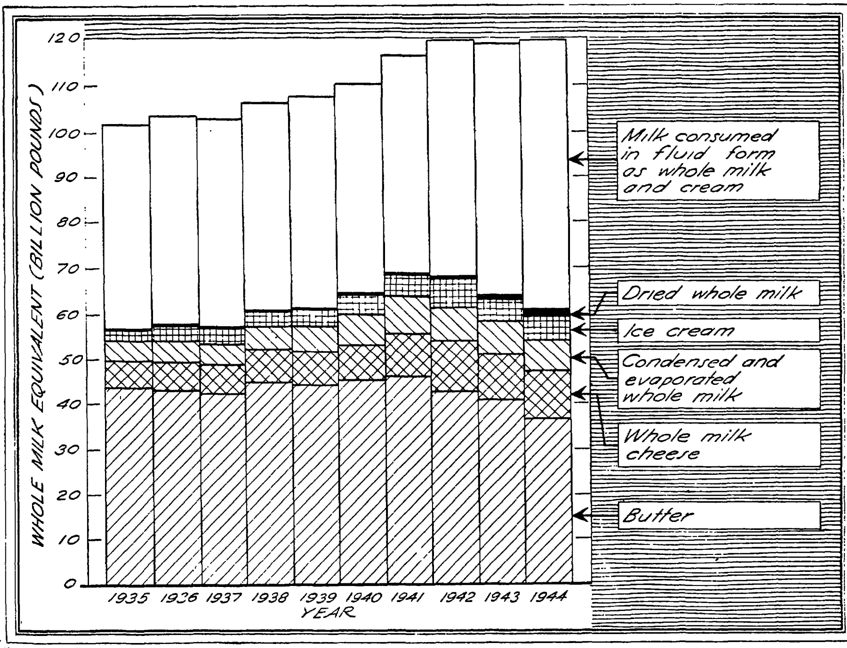
A general prejudice against the use of fluid skim milk as food has existed among our people, presumably mostly because so much of it has been fed to animals. In what degree skim milk is less palatable than whole milk is a question each individual must answer for himself. But the nutritive value of skim milk is not a matter of opinion. It is a matter of fact. Skim milk lacks the fat and the accompanying vitamin A of whole milk, but is equally rich in protein, lactose, calcium, phosphorus, and riboflavin. The diets of many individuals lack adequate calcium and riboflavin. Most of the skim milk used as food in the fluid condition is consumed as chocolate milk and cultured buttermilk. This indicates that added or developed flavor is an effective means of making skim milk attractive as a drink and has led to efforts to produce other flavored milks. The canned caramel-flavored milk, developed by the Bureau of Dairy Industry in conjunction with a manufacturer of evaporated milk, is one result of such efforts, but, since the recommended formulas include some fat, it is not strictly a skim-milk product.

The conversion of skim milk into cottage cheese is a convenient means of concentrating the protein for easier distribution and for marketing in a more popular form. Nutritively, cottage cheese lacks most of the riboflavin, lactose, and minerals of skim milk, but it is an excellent source of protein. Improvements in the texture, palatability, and uniformity of cottage cheese in recent years, resulting from work in the Department and several State experiment stations, have increased its popularity.

Skim milk in its concentrated forms is a convenient source of nonfat milk solids in ice cream. The proportion that can be used has been limited by the tendency of the lactose to crystallize in the ice cream. Because the crystallized lactose is hard and slow to dissolve, the ice cream sometimes had an objectionable sandy texture. To solve the problem, a low-lactose skim milk has been developed.

If skim milk is concentrated sufficiently to cause lactose to crystallize, it becomes so viscous that the crystallizing lactose is finely divided and difficult to separate, but if cane sugar is added to the skim milk before evaporation the concentrated skim milk is thin and the lactose crystals are large and can be separated easily by filtering in a centrifuge. Since cane sugar is needed as an ingredient of the ice cream, it can be supplied in the skim milk as suitably as at a later stage. The lactose removed from the skim milk is a valuable product. This procedure has been used profitably in dairy plants that make ice cream.

The use of fluid skim milk in bread and other bakery products is limited, largely because of its perishability and its bulk. Plain and sweetened condensed skim milk are popular sources of milk solids in bakery products, the latter being an especially convenient form when both milk solids and sugar are required. Dried skim milk is the form most generally preferred for incorporation in foods because of its high degree of concentration and its excellent keeping quality. It improves the texture, physical appearance, and flavor of many food products, and increases their nutritive value.



The increasing trend of milk production before the war would seem to indicate that the yield of 1944 would have resulted without wartime demands.

The largest use of dried skim milk is in bread. Department chemists showed in 1927 that the heating of skim milk to 85° to 95° C. for a short period before drying had the effect of improving the baking quality of a bread dough mix in which the dried skim milk was used. As a result, practically all the skim milk dried for use in breadmaking in this country is given this heat treatment before drying.

When only the protein of skim milk is required, as in cheesecake, pot and bakers' cheese are used. In cities in regions of meager milk supply it has been the practice for some years to make cottage cheese from reconstituted dried skim milk. Recently technicians have demonstrated that a satisfactory bakers' cheese can be made from dried skim milk. This makes it possible for bakers in large cities at a distance from milk-producing areas to obtain freshly made bakers' cheese.

One possibility of utilizing both skim milk and surplus potatoes is in making a wafer containing one-third skim-milk solids and two-thirds potato solids. Boiled potatoes and skim-milk solids are thoroughly mixed and seasoned and the mixture is extruded as a ribbon, which is then dried and toasted to a light brown. These wafers have a cheese-like flavor and the texture of potato chips. Having no fat, they will keep for a year or more. This special product has not yet been commercialized, but in the procedures involved are suggestions for many similar products.

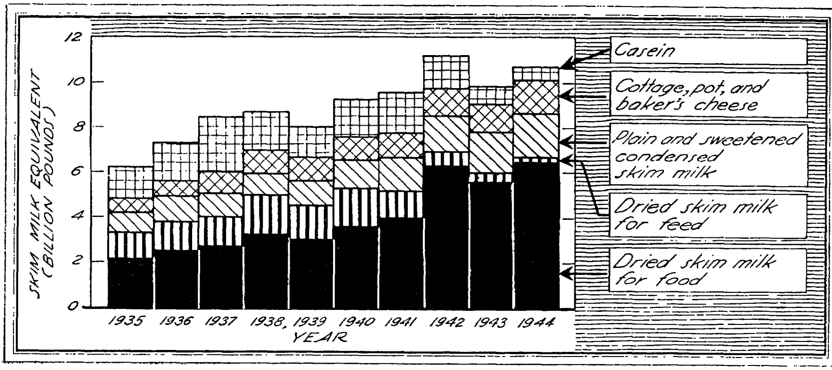
The tendency of skim milk to foam when it is agitated is a troublesome factor in several dairy processes, but this property has been utilized to advantage in preparing home-made fruit whips. Sugar and fruit pulp are added to dried skim milk that has been reconstituted with one-half the usual quantity of water, and air is whipped in until the volume of the mixture is increased from one and one-half to four and one-half times the original. These whips are perishable and hence of no direct commercial interest, but this property of whipping can be put to use in many ways in home and restaurant kitchens.

Casein

The only industrial products manufactured directly from skim milk are acid-precipitated and rennet-precipitated casein, which are relatively pure chemical products. Purified casein is suitable for food, but it is not necessary or even desirable that casein be purified for food use. Cottage cheese and cheeses of the harder varieties are essentially casein of the acid-precipitated and rennet-precipitated varieties, respectively, that have not been freed from other food substances present in milk. But, for industrial use, it is necessary that casein be refined by removing the non-protein organic nutrients to as great a degree as possible.

The chemical differences between acid-precipitated casein and rennet casein are not well understood, but a mixture of rennet casein with a small proportion of water is characterized by its formation of a plastic mass that is suitable for the manufacture of buttons and many other articles, such a umbrella handles, buckles, and costume jewelry. Plastic casein would have greater use were it not that no satisfactory means have been discovered to prevent the finished products from expanding in humid air and contracting in dry air. Efforts have been made to find plasticizers for casein so that it can be used as a molding powder rather than as an extruded plastic, but these efforts have been only partially successful.

The average quality of the acid-precipitated casein produced in the United States has improved markedly in the past 20 years. The devising of the grain-curd process in the Bureau of Dairy Industry and the development by several manufacturers of continuous processes of manufacture, all requiring careful control of acidities and effective washing, have been the major contributions to the wider production of uniform, high-grade casein. The quality of casein is highly important to the paper-coating industry, which used about three-fourths of the total supply in the prewar years. Quality is of less importance to the casein adhesive and casein paint manufacturers, who used 10 and 5 percent, respectively, of the prewar supply. For the newer uses in fabrication of synthetic rubber and in making casein fiber, it is essential that the casein be of high grade.



From 1935 to 1944, the amount of dried skim milk used of food has nearly tripled.

The popular and relatively new water-emulsion paints usually contain casein to the extent of about 3 percent of the total solids. Casein is used in these paints principally for its emulsifying action, but it also functions as a binder. The use of the insecticide DDT in water-emulsion paints is expected to increase the market for casein.

Although the quantity of casein used in synthetic rubber is small, this use is important, since no adequate alternative substance has been found. The casein is said to act as an internal lubricant, and thus prevents excessive heating of synthetic rubber articles, such as tires, when they are flexed during use. The quantity of casein required in the future for this purpose depends, obviously, on the extent to which synthetic rubber is used, but there is a probability that casein will be used also in tires made from natural rubber.

A thin, transparent, wrapping material made from casein was in limited commercial use in the early 1930's. Its production was abandoned because it developed a cloudy appearance and brittleness. A recent patent on improvements in the manufacturing process indicates the possibility that it may again be on the market.

Casein has been used in small quantities in the textile industry for years for bonding, loading, finishing, and waterproofing fabrics, but only since 1940 has there been commercial development from casein of an artificial fiber that seems to be finding a definite place among our textile fibers. Application for the first practical patent for making fiber from casein was filed in 1935 in Italy and commercial production was begun there the following year. The first of a series of eight patents resulting from research in the Bureau of Dairy Industry was issued in 1939 and, in the 6 years immediately following, about 40 United States patents were granted to other inventors on phases of this development. Currently, the production of casein fiber in this country, which began only a few years ago, probably approaches 10 million pounds a year.

The conversion of the casein of skim milk into textile fiber is not a process that can be carried out on the farm. The casein must be made by a controlled procedure possible only in a dairy plant or a plant making casein exclusively. The conversion of casein into fiber requires the knowledge and experience of textile engineers and equipment similar to that of plants producing viscose rayon. The casein is dissolved in alkali, various other substances are added, and the solution is extruded through the fine apertures of a spinneret into a bath containing acid and dehydrating and hardening agents. Next, the fiber is chemically treated. It is then cut into staple lengths, after which it it either felted in mixture with hair or wool or spun into yarn, which is woven into fabrics in mixture with cotton, rayon, or wool yarn. Most felt hats sold in the United States contain some casein fiber; garments and fabrics containing casein fiber may be purchased in stores.

Among the characteristics that have established casein fiber in the textile field are its property of felting in mixture with hair and wool whereby it acts as an extender of these more expensive fibers; the soft feel imparted to fabrics that contain it; and the fineness of fiber possible—finer than the finest wool. The fact that casein fiber has somewhat less tensile strength than wool, especially when it is wet, has prevented its being woven into fabrics without admixture of other, stronger fibers. Fibers from soybean protein and from peanut protein resemble casein fiber but do not equal it, and have not yet been commercialized; the synthetic nylon is similar chemically to casein and offers serious competition since it is now being produced as a wool-like fiber.

Buttermilk and Whey

The uses for buttermilk are similar to those for skim milk. It is a desirable component of bakery products and other foods, the condensed and dried forms being the most convenient ones. Fluid and condensed buttermilk are fed to animals and dried buttermilk is fed in mixed feeds. Casein made from buttermilk is different in many respects from skim-milk casein. For most purposes it is less desirable than casein from skim milk, but for casein paints it is especially suitable, provided it is used in paste form without being dried.

Despite the need in our diets for the calcium, phosphorus, and riboflavin readily available in whey, we drink no whey and consume as food practically none of it in its concentrated forms, except as a component of other foods. Feed uses account for the largest proportion of whey, increasing amounts being used in the dried condition, especially for feeding chickens. Dried whey, besides being of high general nutritional value, is of specific use in the chicken industry, since the lactose acts as a preventive of coccidiosis, and riboflavin is essential to hatchability of eggs and optimal growth and aids in preventing curled toe paralysis. The most

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recent advance in manufacturing dried whey for feeding chickens is the use of bacteria to synthesize riboflavin in the whey before drying. This procedure was commercialized during the war when sufficient equipment was not available to dry enough whey to meet the needs for riboflavin in feed. It is possible to concentrate the riboflavin in whey, either normal or enriched, by absorbing it on lactose. By partly concentrating the whey, some of the lactose is caused to crystallize. On concentrating further, more lactose crystallizes, carrying with it most of the riboflavin of the whey. By careful regulation of the process, a bright yellow sugar can be obtained containing 0.3 milligram riboflavin per gram. Four grams of this lactose—about one-seventh of an ounce—can furnish a person's full daily requirement of riboflavin. This yellow lactose is also suitable for addition to bread and other foods to increase their riboflavin content.

Whey can be used as an ingredient in other foods either as fluid or concentrated whey. Fluid whey may be combined with vegetable juices, such as tomato juice, to produce beverages of improved food value, or with tomatoes, peas, or beans to produce soups. In acid soups, such as tomato, whey has the advantage over skim or whole milk that it does not form lumpy curds on heating, but, instead, gives a fine-textured, smooth body.

Sweetened condensed whey is a new product developed to provide a cheap nonperishable form of whey solids to be used wherever sugar is also needed. It is suitable for use in candies, especially those of the fudge type. It adds nutritive value, gives a smooth body, and aids in keeping the candy soft and fresh. Sweetened condensed whey has been used successfully also in canned puddings, and dried whey in canned brown bread. Formulas for all of these products have been developed in the Bureau of Dairy Industry.

Whey protein, isolated as a byproduct in the manufacture of lactose and lactic acid, finds use in feeds, and efforts have been made to isolate it in a condition suitable for use as food. One method that has been successful on a laboratory scale is to condense whey, remove the lactose that crystallizes, and dialyze it to remove the salts. Another method that shows promise is to stir spray-dried whey with 70 percent alcohol and to filter out the whey protein promptly. Lactose crystallizes slowly from the filtrate and, after its removal, the alcohol may be recovered and the remaining liquid used as a source of riboflavin.

Lactose and Lactic Acid

Lactose has been made from casein whey for many years and used mainly in infant foods. The suddenly increased demand during the war for lactose to use in producing penicillin came at a time when domestic casein production was greatly reduced, but when cheese production was greatly increased. Consequently, cheese whey was much more readily available than casein whey. The Department had accumulated information on the making of lactose from cheese whey which was published as six practical methods, each adapted to some special condition or requirement. These processes differ in cost of operation, in the purity of the lactose produced, and in the solubility of the whey protein obtained as a byproduct. Several companies have been producing lactose from cheese whey and have thus bolstered the supply needed in making penicillin.

Fermentable sugar present in dairy byproducts can be utilized in the production of alcohol and organic acids. One plant in the United States is producing alcohol from whey and converting the alcohol into vinegar. The only organic acid being produced directly from whey by commercial fermentation is lactic acid. The Bureau of Dairy Industry devised a process whereby more than 90 percent of the lactose in whey is converted to lactic acid in 24 hours. This is a continuous process, in which raw whey flows in at one end of a tank and fermented whey flows out at the other. The commercial process is a batch process requiring a 48-hour turn-over. In brief, the whey is fermented by a bacterial culture, the lactic acid being neutralized from time to time by lime in order that the bacterial action may continue. When the sugar is all fermented, the whey is boiled to coagulate the whey protein and the clear liquid is evaporated to cause calcium lactate to crystallize. The calcium lactate is removed on a filter and, after purification, is treated with sulfuric acid to convert it to lactic acid.

If increased quantities of lactic acid are to be made, greater use for it must be found. To this end two bureaus of the Department have developed procedures for converting lactic acid to acrylates. These acrylates, when polymerized, are flexible, glass-like substances that have use as plastics and in waterproofing cloth, and that can be converted into rubber-like materials. But acrylates can be made more cheaply from other starting materials and this has aroused interest in ways of cheapening the present expensive method of refining—which is the largest proportion of the cost of lactic acid. This acid cannot be crystallized or distilled by any method that is commercially practical, but it can be combined with alcohols to give lactates that can be easily distilled and thus purified. Three patents on such procedures have been issued to workers in commercial laboratories. These purified lactates can be shipped in undiluted form and in inexpensive containers, in contrast to dilute lactic acid that must be shipped in expensive, noncorrodible containers. At the point of use the lactates can be converted back to lactic acid of any desired concentration by boiling with water. It is reasonable to expect that some of the needed reduction in cost of lactic acid to the user can be attained by application of these methods of refining and handling.

Another use for lactic acid that is not yet commercialized is in lacquers and protective coatings. When a lactic acid solution is heated, water distills off and the lactic molecules combine with one another to form resinous substances of increasing viscosity and insolubility. Public service patents have been issued to Paul D. Watson of the Bureau of Dairy Industry who has discovered that these resins may be combined with oils or with small percentages of metals to give lacquers. Baked on glass or metal surfaces, these are tough, elastic, and firmly adherent coatings that resist the action of steam, acids, and dilute alkalies, and are affected only by strong alkalies and few organic solvents. These coatings have been tested with satisfactory results on milk cans, pails for cottage cheese, cans for evaporated milk, mechanical pencils, and cigarette lighters.

THE AUTHOR

Earle O. Whittier is a research chemist in the Division of Dairy Research Laboratories of the Bureau of Dairy Industry, where he has worked for 25 years on chemical problems related to milk and its byproducts. He was educated as a chemical engineer at the University of Maine. His published researches on the chemistry of milk won for him the 1943 Borden award of the American Chemical Society.