



Uses of Whey in the Farmstead Setting

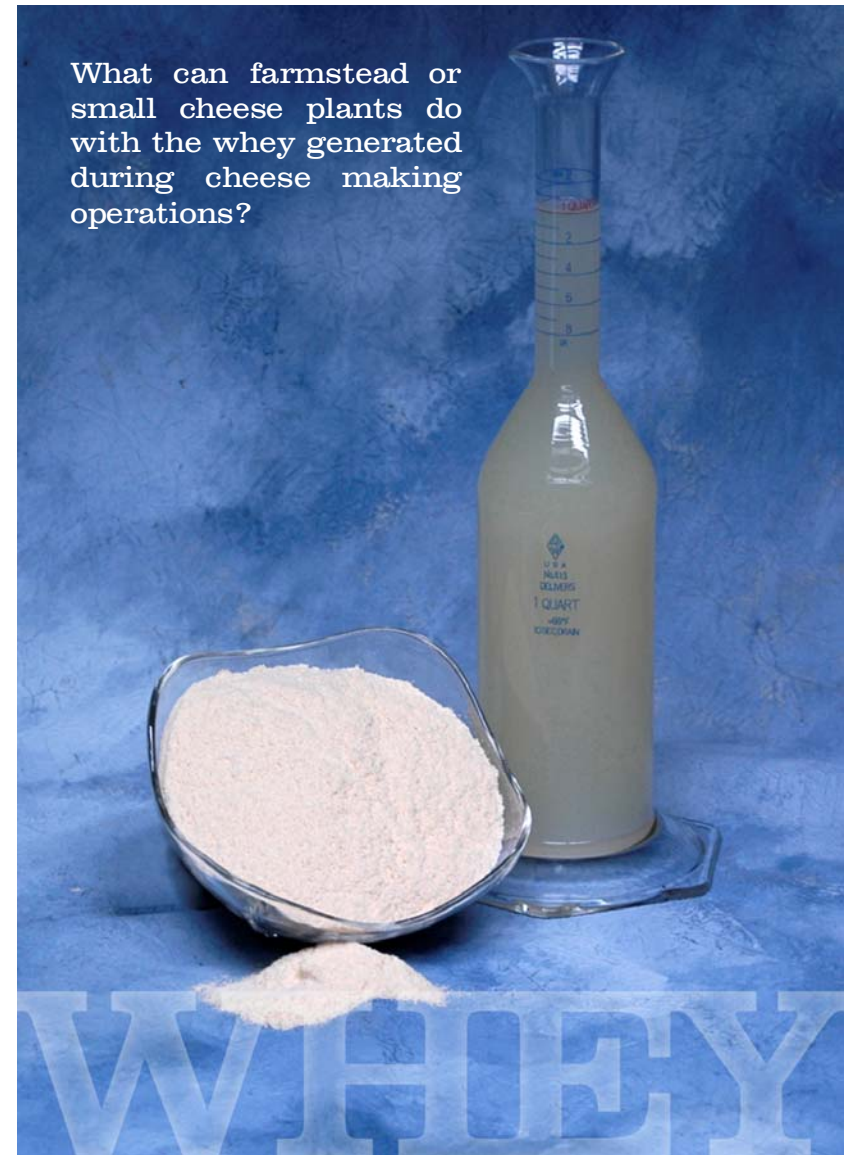
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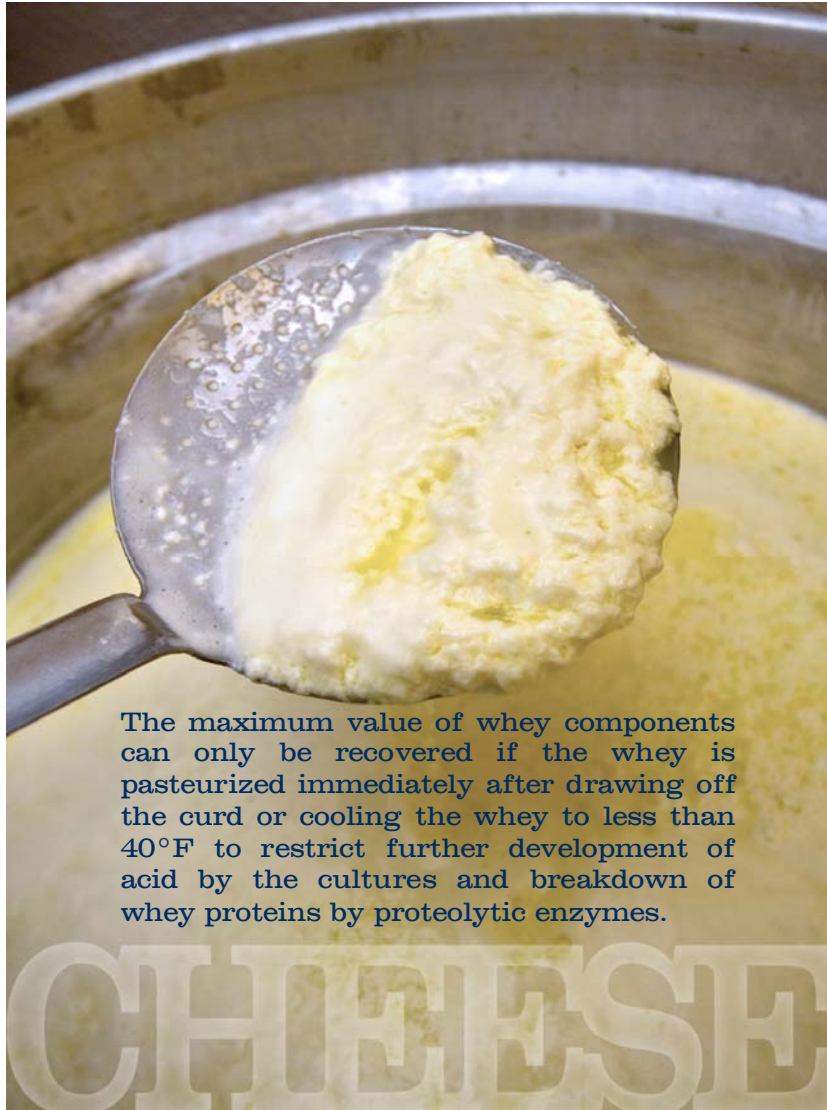
Introduction

Whey is a by-product of the cheesemaking process which represents 90% of the volume and 50% of the solids of milk used in the manufacture of cheese. It is a very dilute by-product stream with only 6-7% solids and one-fifth of the initial milk proteins present. Commercial cheese plants will process whey to recover those milk solids for food or feed ingredient markets. This provides those plants with revenues from those solids to help offset the cost of milk used for manufacture of natural cheeses.

Farmstead or small cheese plants find it difficult to process whey due to economy of scale. Many of the plants are too small to justify the capital investment for further processing of whey and have insufficient volumes to justify storage and transportation of whey to larger whey processing facilities. Since whey contains 6.0 to 7.0% solids and has a biological oxygen demand (BOD) of over 32,000 mg/liter, it can not be discharged to waste treatment systems used for treating dairy plant wash waters. These limitations beg the question, "What can farmstead or small cheese plants do with the whey generated during cheesemaking operations?" In this bulletin, we will survey possible options for uses of whey in farmstead cheesemaking operations. We will expand on the four Fs for whey utilization: food, feed, fuel, and fertilizer. Economic feasibility of each option will depend on local regulations, markets and capabilities of the cheesemaker.

What can farmstead or small cheese plants do with the whey generated during cheese making operations?





The maximum value of whey components can only be recovered if the whey is pasteurized immediately after drawing off the curd or cooling the whey to less than 40°F to restrict further development of acid by the cultures and breakdown of whey proteins by proteolytic enzymes.

Types of Whey

Each cheese variety will yield whey with a characteristic acidity and ash content. Rennet-set cheeses, e.g., Cheddar, Mozzarella, Swiss, Brick, and Gouda will produce sweet whey with low levels of acid and ash. Acid-set cheeses, e.g., Cottage, Cream, and Chevre will produce acid whey with higher levels of acid and ash. Sweet whey will typically have a titratable acidity of 0.10 to 0.20% lactic acid and a pH of 5.8 to 6.6. Acid whey will typically have a titratable acidity of 0.40 to 0.60% lactic acid and a pH of 4.0 to 5.0.

Sweet whey will typically have approximately 0.4% ash while acid whey will have 0.7%. The maximum value of whey components can only be recovered if the whey is pasteurized immediately after drawing off the curd or cooling the whey to less than 40°F to restrict further development of acid by the cultures and breakdown of whey proteins by proteolytic enzymes. Sweet whey will have few restrictions on potential uses that we will be listing. On the other hand, acid whey may have some limitations due to the higher acid present in the whey. Possible limitations will be listed in our discussion.

Food Uses

Whey Cheeses

There are generally two types of procedures for producing natural cheeses from whey:

- 1) heating the whey, with acidification, to separate the protein and fat curd, incorporation of additional milk constituents and draining, e.g., Ricotta;
- 2) slow evaporation of whey in open vats until the lactose forms a brown, caramelized mass, e.g., Mytost and Gjetost. Precipitation of the heat-coagulable proteins for Ricotta will recover only 10% of the whey solids so the deproteinized whey is still a byproduct to deal with.

Ricotta

Ricotta is made from sweet whey obtained from the manufacture of other natural cheeses, e.g., Cheddar, Swiss and Mozzarella. About 5 to 10% skim milk or whole milk is added to the whey to raise the milk solids and improve the precipitation of the whey proteins and improve the final cheese flavor. The whey mixture is heated to 185°F or higher and citric acid or vinegar is added to drop the pH down to 5.4. The curd will rise to the surface and is allowed to rest. It is then dipped from the surface of the whey and placed in perforated tins or lined hoops and allowed to drain. The product is then placed in tubs or plastic containers and refrigerated. A detailed make procedure is outlined by Kosikowski and Mistry (1).

Ricotta cheese is a fresh cheese with a soft, delicate body and a pleasant, slight caramel flavor. It is primarily used as an cheese ingredient in lasagna and ravioli and is used in bakery applications. Since it is a high-moisture, fresh cheese, it is very susceptible to microbial spoilage so good sanitation practices are needed when handling the curd.

Mizithra

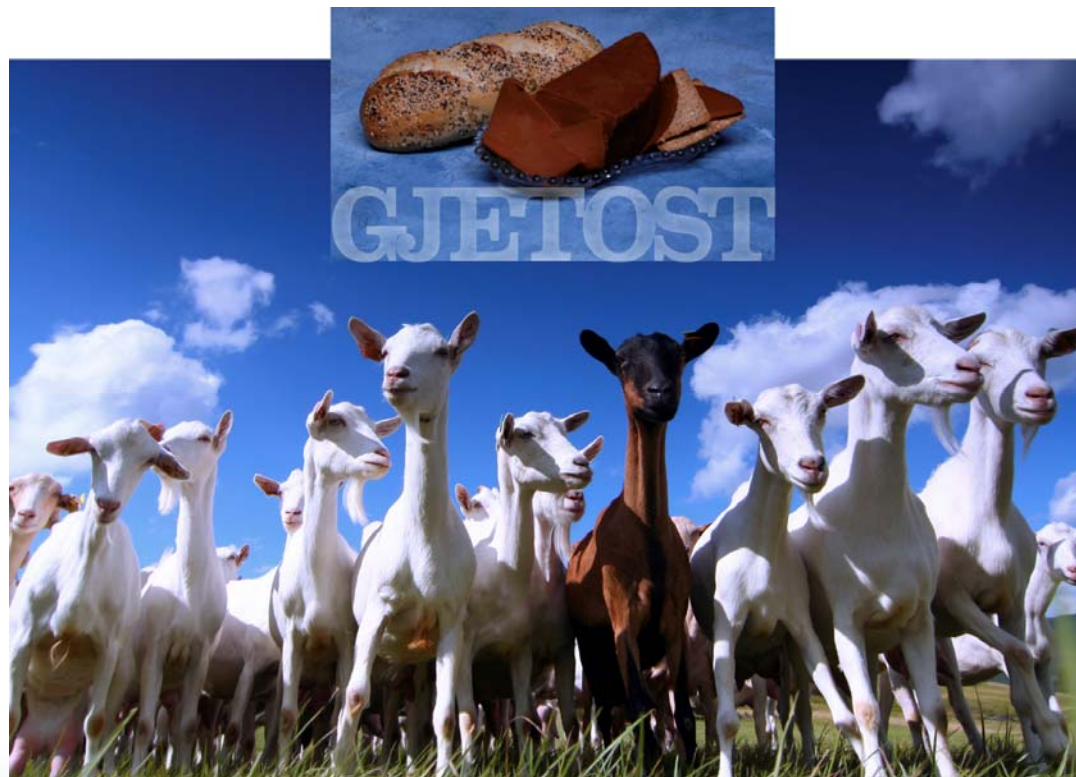
Mizithra is a traditional Greek cheese manufactured from whey by heating at a temperature of 190-196°F (World Cheese Exchange Database, www.cdr.wisc.edu). The whey for Mizithra production is always subjected to filtration before its use in order to remove any existing curd grain. If the grains remain in the whey, they become hard during the whey heating and reduce the quality of Mizithra.



After filtration, the whey is usually delivered into circular cheese vats, where it is heated by using steam which is either directed to the double wall of the cheese vat or infused directly in the mass of the whey. The rate of heating is such as to attain the temperature of 190-196°F in 40-45 min. Heating of the whey is taking place under continuous stirring. When it reaches a temperature of 176-180°F, small curd particles appear because of the denaturation of whey proteins. At this stage, heating is speeded up until the whey obtains a temperature of 190-196°F and stirring is slowed and finally is stopped when a very thin layer of coagulum is formed on the surface of the whey. If the whey pH is above 5.2, citric acid or vinegar should be added to drop the pH to 5.2 for good precipitation. In case Mizithra is going to be used fresh, the whey is heated at lower temperatures while it is heated at higher temperatures when the product is to be dehydrated afterwards. At those temperatures, the curd remains for 15 to 30 min to be cooked and thereafter is placed in special molds for drainage. Mizithra is used in cooking or is eaten fresh. Ziger and Schotterliger are the German names for whey (whey-protein) cheese, which is made by precipitating the whey proteins in sweet whey with heat and acid, similar to the Ricotta or Mizithra process (World Cheese Exchange Database, <http://www.cdr.wisc.edu/>).

Mysost and Gjetost

Mysost is made from cow sweet whey and Gjetost is made from goat sweet whey. Sweet whey, with added whey cream, is condensed in evaporating pans to 60% total solids and then at a higher temperature to 82% solids. The brown concentrate is then heated to about 203°F until the desired brown color and intensity of caramel-like flavor is attained. The plastic mass is transferred to a kneading box and stirred while cooling to prevent large lactose crystals. The still warm plastic mass is conveyed to cubical boxes and cooled until it can be cut and packaged. The finished cheese contains about 33% fat and 40% lactose. A detailed make procedure is outlined by Kosikowski and Mistry (2).



Confectionery

Sweet whey contains about 5.0% lactose and 0.6-0.7% whey protein. Upon heating at higher temperatures, lactose is caramelized and reacts with the whey proteins to give a tan or brown color and characteristic caramel flavor which is important in confections and bakery products

Sweetened Condensed Whey

Fluid wheys, because of their high water content, cannot be easily used for candy manufacture. To facilitate its use in candies, whey is concentrated and sugar is added to produce a sweetened condensed whey product (3). Whey is pasteurized at 145°F for 30 minutes, the required amount of sugar added, and the mixture evaporated in a vacuum pan. The sweetened condensed whey contains 38 to 40% whey solids and an equal quantity of sugar (4). The condensed product is then cooled to 95°F and stirred for 3 or more hours at room temperature to produce the desired small lactose crystals. The production process for manufacture of sweetened condensed whey is detailed by Ramsdell and Webb (3). The optimum concentration of ingredients for sweetened condensed whey was 38% whey solids, 38% sugar and 24% water. Sweetened condensed whey had a shelf-life of 3 months when stored at room temperature. Changes in the product during storage were a slight darkening in color and a slight increase in viscosity.

Whey candies

With the use of sweetened condensed whey, several types of candy can be produced, including fudge, caramels, and taffy. Make procedures for these types of candy are detailed by Webb (4).

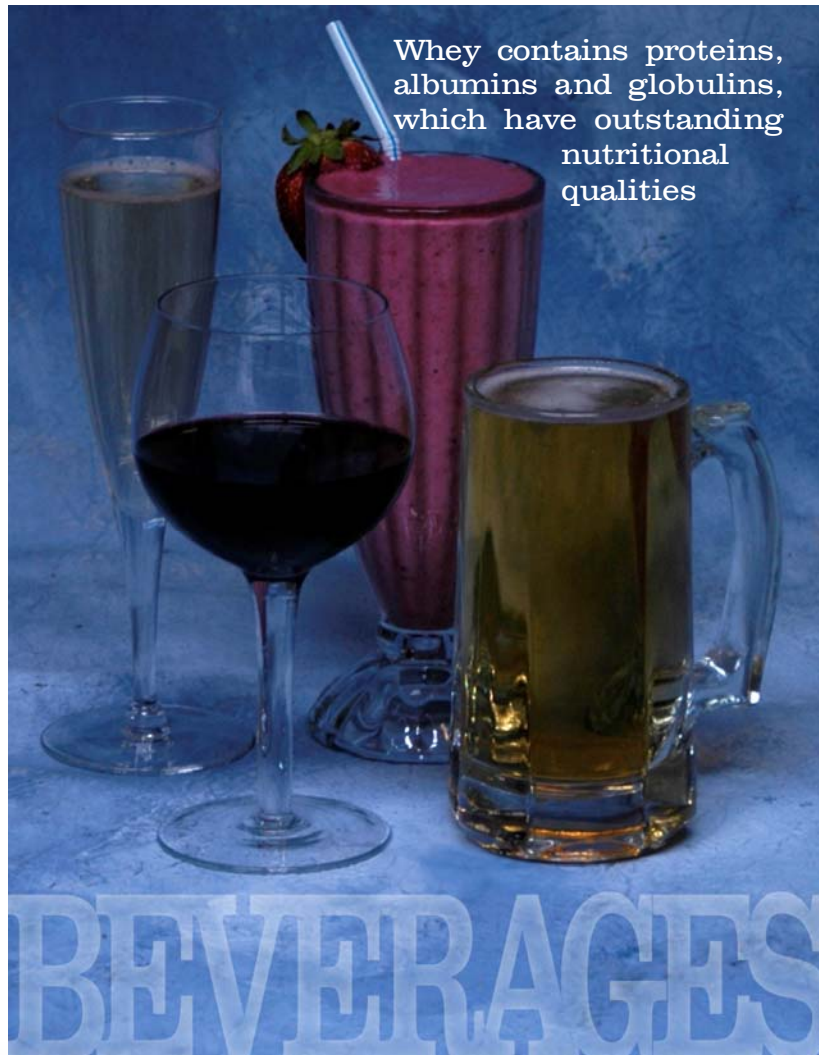
Dulce de leche

In Latin American countries, whey is used to manufacture a confectionery product called Dulce de leche (5). This product is produced by boiling a mixture of 10 parts of whey or milk and 20 parts of sugar to more than 65% total solids. At this concentration, the product is a caramel-flavored syrup that is pourable and can be used on pancakes, waffles or toast (6). In some areas the product is concentrated to over 70% solids, cooled and pressed into bars for confectionery use.



Beverages

Whey contains proteins, albumins and globulins, which have outstanding nutritional qualities. It also contains lactose which is a carbohydrate that provides energy but is less sweet than sucrose. Whole whey drinks will have a turbid appearance and occasionally flocculation will occur upon storage. The use of deproteinized whey or whey permeate will tend to reduce this problem



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Nutritious beverages

Fruit-flavored drinks containing 75-90% whey have been developed by Nelson and Brown (7). Suitable flavorings included peach puree (20%), strawberry (10%), and red raspberry (10%). The preparation of the flavored whey drinks involved concentration to 18-20°Brix and addition of citric acid to bring the pH down to 3.6. At low pHs, the proteins in these whole whey drinks may tend to precipitate and form deposits in the container. Drinks from deproteinized whey or whey permeate avoid this problem if the market is sensitive to the residue. Further information on whole whey drinks produced internationally is available in several references (8,9).

Deproteinized whey or whey permeate provide an improved base for beverages with highly resorbable lactose, important mineral salts and vitamins. After acidification of the permeate with organic acids, both whey lemonades and still whey beverages are obtained by the fermentation of lactose to lactic acid (8).

Alcoholic beverages

Several fermented whey beverages with varying alcohol contents have also been successfully produced. These drinks may be classified as beverages containing less than 1.5% alcohol, whey beer, whey wine and whey champagne.

Whey beverages with a low alcohol content

These drinks are produced from whey permeate by fermenting the lactose with *Kluyveromyces fragilis* or *Saccharomyces lactis* to an alcohol content of 0.5-1.0 %, adding flavoring, sweetener and bottling. Acid whey permeate would lend a pleasantly tart flavor to the product. One such product developed in Poland (8) is produced by inoculation of acid whey permeate with kefir fungi (30% addition, 5 hr incubation at 77°F). The fermented whey beverage contains 0.6-0.7% lactic acid and 0.8-0.95% alcohol.

Koumiss-like drinks can be produced with mixtures of whey and buttermilk or by mixing whey and milk for fermentation. Guan and Brunner (10) developed a koumiss-type product with a skim milk/whey blend in which the mixture has 2.5% added saccharose, inoculated with 2.5-10% of a culture containing lactobacilli and yeast and incubated at 78°F for 12-15 hr to a lactic acid content of 1%. The fermented product is stirred, homogenized and bottled in glass bottles. The bottles are stored at 68-77°F for 2 hr to produce some CO₂ and alcohol, and then cooled to less than 40°F. The koumiss-like product has a shelf life of 4 weeks at 40°F.

Whey beer

The production of beer from whey has been carried out since around the 1940s. Whey is suitable for the production of beer for the following reasons (8):

- the whey protein content and quantity of milk minerals in the colloidal state form the basis for a high degree of CO₂ binding,
- whey, like wort, has a high mineral content,
- a caramel-like flavor develops, similar to that of kilned malt, mainly as a consequence of the browning reaction of lactose,
- lactose in whey is only slightly sweet and does not alter the flavor of the final beer.

If whey is used for the production of beer, the following problems may occur: microorganisms may be present in the whey, the fat content can destroy beer foam and it may have a slightly salty taste. Several types of European whey beers are described by Sienkiewicz and Riedel (8).



Whey wine

Cheddar cheese whey was successfully used to produce whey wines of acceptable quality at Oregon State University (11). Raw whey was clarified by heating to 180°F for 5 minutes and filtering. The cooled whey filtrate had 22% dextrose and 100 ppm of SO₂ added before inoculation and fermentation. The whey was then fermented for 1-2 weeks with Montrachet wine yeast followed by fining with bentonite, filtration and bottling. Whey wines blended with berry wines or flavored with synthetic citrus flavors were found acceptable by taste panels.

Palmer and Marquardt (12) also described a process for whey wine in which natural whey is converted to a clear fermented beverage base in a 5-step process of clarification, deproteinization, fermentation, de-ashing and polishing filtration. The process resulted in a wine with the following composition: 8.0% alcohol by vol., 6-9% invert sugar for sweetness, 2-4% natural flavor extract, and 0.2-0.5% organic acid. Panelists found no significant differences between a targeted flavored wine and the fermented whey wine. However, economic projections indicated a significantly lower market price for whey wine compared to commercial flavored wine. Yoo and Mattick (13) indicated that total production of alcohol increases with lactose concentration to a maximum in whey of 12% lactose. An ethanol concentration of 10% was obtained from a 10% acid whey solution containing 16% added sucrose.



Whey champagne

Russian workers (14) have developed a process for producing a sparkling whey wine from acid whey. The deproteinized whey is pasteurized, cooled, inoculated with *Lactobacillus acidophilus* or *Lactococcus lactis* and fermented for 2 hr at 106°F. The yeast culture is then added along with 8-10% sugar, the whey is filled into champagne type bottles, sealed and held at 45-50°F for 3-4 days to produce alcohol and CO₂.

Polish workers (8) have reported on a process for producing whey champagne. For production of 1000 liters of champagne, 200 liters of deproteinized acid whey, 90 Kg of saccharose, 10 Kg of caramel sugar, 1.5 Kg of dry yeast, 0.1 Kg of fruit essence and 720 liters of water are used. The whey, water and sugar are blended together and pasteurized, followed by addition of the yeast and fruit essence and bottling. The whey champagne is fermented in the bottle at 65°F for 8-12 hr.

The use of cheese whey as a base for manufacture of a variety of beverages, both alcoholic and non-alcoholic, was reviewed by Holsinger et al. (15).

NOTE: Production and sale of alcoholic beverages is regulated by the Alcohol and Tobacco Tax and Trade Bureau of the U.S. Dept. of the Treasury. Code of Federal Regulations Title 27, 27CFR24.75 allows for the production of up to 100 gallons of wine annually for personal or family use without payment of tax. For information on permitting and payment of tax for production of alcoholic

beverages for sale, go to the Alcohol and Tobacco Tax website at: <http://www.ttb.gov/>

Use of whey should lead to better kneading of bread dough, to better yeast fermentation, to a lighter crumb color, and to a greater porosity and improvement in the crust.



Other foods

Because of its nutritional value of various components, whey is used in numerous food applications, e.g., bakery products, ice cream, puddings and prepared mixes. However, these applications generally require the whey to be concentrated or dried to eliminate some of the excess water that dilutes out the whey components. In most cases, commercial whey processors can concentrate whey and produce dry sweet whey more efficiently than farmstead cheese plants due to the economy of scale. In some cases, liquid whey may be used to replace water in some bakery product recipes (8). Use of whey should lead to better kneading of bread dough, to better yeast fermentation, to a lighter crumb color, and to a greater porosity and improvement in the crust. However, one limiting factor in the use of liquid whey is the perishability of the liquid whey and the tendency for cheese cultures to continue to produce acid during storage. Russian workers found that the maximum amount of water that could be replaced in bread and roll recipes was 13-18% (8).

Feed Uses

Whole whey is a highly nutritious byproduct of the cheese industry that can be used effectively in animal diets of animals for efficient production of meat and milk. Whey protein is one of the highest quality natural proteins having a protein efficiency ratio of 3.2 as compared to 2.5 for casein. Whey is classified as an energy feed since 4.8 to 5.1 % out of the 6-7% total solids is lactose and in most feeding applications, it is the protein component which must be supplemented to balance rations (16). Other nutritional whey components of interest include calcium (0.045%) and phosphorus (0.04%). However, deproteinized whey or whey permeate has little or no value as animal feed since the protein has been removed.

Dairy cattle

Researchers have successfully fed liquid whey to lactating cows (17, 18). Milk production was not affected when whey replaced all or part of the water fed to lactating cows (17). It was estimated that one lactating cow can consume the whey from the production of three to five average cows (17). Normally whey intake must be limited in lactating animals so as to permit the ingestion of sufficient dry matter to support milk production.

Fiber is the primary source of energy for dairy cattle and the sudden introduction of large quantities of whey can cause digestive upsets (16). Lactose is digested more easily than fiber and may result in excessive acid/gas production. To avoid such problems, whey should be introduced slowly and sufficient roughage included in the ration to stimulate rumen activity. A minimum of 4.5 lb. of long stemmed hay is recommended to maintain rumen activity on whey fed animals (16). Whey consumption of lactating animals varies from about 12 to 18 gallons per day. Dairy heifers and pregnant dairy cows, consuming 10-13 gallons of whey actually exceed their energy requirements and tend to get fat on whey (16). Hence, they should be restricted to lesser amounts of whey to allow some latitude for balancing the ration. About 100 lb of whey is equivalent nutritionally to 7 lb of corn or barley (19).

Generally cattle adapt more quickly on a wet diet than on free choice whey/dry ration regime. Initially, whey should be diluted

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4:1 with water and an increase in whey content of 20% per day should be conducted until full strength whey is being fed. Rapid introduction of whey can lead to very loose feces. Feces tend to be softer when animals are on a whey feeding program (16). Consumption of excess whey, combined with the lack of sufficient roughage, is the most common cause of bloat in cattle. Animals which are under stress appear to be more susceptible to whey bloat (17). Wet feeding gives better control over whey intake but a concentrate to forage ratio of 60:40 should not be exceeded for lactating cows (16). The moisture content of the ration for dairy cattle should not exceed 35% or feed intake will be limited. Acid whey has been shown to cause some erosion of teeth in dairy



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cattle, so sweet whey should be pasteurized immediately after draining from the vat to inactivate the lactic acid cultures (19). Whey should also be consumed within 24 hr. of production to ensure maximum nutrient quality. Flies tend to be a problem with feeding liquid whey so good sanitation and fly control is needed in the feeding area.

Beef cattle

Liquid whey can serve as a satisfactory feed for growing steers and heifers. Steers on pasture consumed 12 gallons of whey per day and gained satisfactorily (20). In USDA studies (1), steers fed liquid whey free choice consumed 28 to 31% of their dry matter as whey and gained weight as rapidly as those fed the control ration. Several cases of bloat on the free choice acid whey treatment occurred at the beginning of the experiment. This was corrected with feeding timothy hay at 0.4% of body weight for the remainder of the experiment. Intake of acid whey can be maximized by restricting grain feeding; however, reduction in gain, final body weight, grade, and carcass fat cover will be experienced. Liquid acid whey had an average digestibility of 82.6% of dry matter, 68.8% of protein, and 84.2% of organic matter (22).

Six to eight month-old heifers receiving whey with no grain gained as much weight as those receiving 5 lb of grain daily while heifers receiving both whey and grain made 19% faster gains (17). Heifers receiving whey with no grain consumed 34% of their dry matter as whey while those fed grain also consumed 21% of their dry matter as whey.

A few problems experienced in feeding whey have been initial scouring at high levels of consumption, problems with shelf life and palatability, possible excessive urination at high intakes, and problems with fly control. However, with the proper management of liquid whey in the rations of beef cattle, good rates of gain can be obtained from the nutrients present in the whey stream.

Swine

Liquid whey has been successfully fed to pigs for many years (23). The general consensus of opinion is that whey can be used to replace about 30% of the dietary nutrients (16). About 2.25 gallons of whey would provide 30% of the nutrient requirement for an 80-130 lb hog on a daily basis. However, Schingoethe (18) reported some studies have shown that pigs may experience diarrhea when over 20% of their dry matter is liquid whey. Generally pigs are started on whey when the body weight reaches about 60 lb. Researchers (16) recommend no more than 20% ration replacement with whey for small pigs.

Liquid whey maintained growth rates at the same level of pigs receiving a corn-based diet and water, despite a reduction in crude protein intake of 33% (24). Liquid consumption by pigs given fresh Cheddar whey was 2-3 times that of pigs given water. Pigs receiving whey plus 3 lb of meal daily had less back fat than the meal and water control group (25). There was a tendency for belly thickness to be greater in pigs receiving whey but there was no significant difference in the area of eye muscle or bacon flavor between the rations (25). Although the dry matter and protein of liquid whey is low, a high voluntary consumption by pigs makes it a good protein supplement in corn-based diets.



Sheep

Anderson (26) reported on a study evaluating digestibility with 3 groups of sheep fed lucerne hay and given to drink whey only, whey and water, and water only. Digestibilities of dry matter for the rations were 71.3, 69.7 and 62.9%, respectively. The dry matter digestibility of whey solids was approximately 87% when whey solids made up 29% of the ration. Rumen liquor samples taken for analysis of volatile fatty acids showed that acetic and valeric acids were lower and butyric acid was higher for sheep given whey.

Poultry

Scott (27) reported that turkey poults do not tolerate lactose well. He reported that lactose caused an increase in the occurrence of enlarged hocks in young turkeys when lactose was present at 3.25% in the ration. With delactosed whey, growth was good without any evidence of enlarged hocks.

Polish researchers (28) reported that with a 5% addition of whey to the broiler feed mixture, carcass quality was improved and feed costs were reduced by 10%. Other researchers (29) reported that with 4% of the carbohydrate replaced with dried whey, the whey containing feed showed significantly better growth, earlier sexual maturity, and more eggs. However, DeLoach and Corrier (30) reported that with 5% whey in the drinking water, a lactic fermentation by anaerobic bacteria in the cecum caused a drop in intestinal pH with the result of decolonization of *Salmonella* bacteria in the gut. This procedure may help in reducing the potential for contamination in broilers but it does not aid in weight gain in the broilers.



Silage additive

Whey concentrate additions can improve the quality of grass and legume silages. The lactose in whey can provide for a quicker fermentation of the silage. With 30% solids whey concentrate, an addition of 7 to 14% provided improved fermentation (8).

Schingoethe (18) reported an addition of 1% whey powder to corn silage lead to an increase in milk yield of 6.5% and to a 7% weight gain in calves.

Fuel and Chemicals

Ethanol

Whey and whey permeate are great substrates for the manufacture of ethanol by lactose fermenting yeasts, e.g., *Kluyveromyces fragilis* and *Candida pseudotropicalis* (31). Alcohol yields ranged from 79-91% of the theoretical yield. Industrial ethanol plants would require large volumes of whey for ethanol production from whey only. However, Cunningham et al. (32) have reported that when whey was used instead of water to make up the traditional grain mash, increased alcohol production was experienced. The quality of alcohol from whey was similar to that of alcohol produced from molasses (33). Opportunities for production of ethanol from whey will depend on the location of an ethanol plant in close proximity to the farmstead cheese plant.

Methane

Methane digesters are becoming more prevalent on dairy farms to treat animal wastes and produce energy. Whey has been shown to be a good potential source of energy when fermented anaerobically to produce biogas (34). Studies showed an average of 36 liters of biogas with about 50% methane and energy content of 228 kcal/liter of whey. Whey and high strength milk wastes can be blended up to 10% in liquid manure storage systems so partnering with another farmer who has a manure digester may provide another opportunity for handling whey in a farmstead setting.

Fungicide

Whey has been reported to have inhibitory properties against various plant viruses. Canadian researchers (35, 36) have reported whey sprayed on barley strongly inhibited contact transmission of the barley stripe mosaic virus and reduced the spread of the virus in the field. They found that much of the anti-viral activity was associated with the whey proteins. A Russian researcher

(37) reported tobacco leaves sprayed with whey for 6 days strongly reduced tobacco mosaic virus activity, especially if it was applied before inoculation of the test tobacco plants with the virus. Whey has also been shown to be effective against cucumber mosaic virus, potato veinbanding virus, and tobacco etch virus (0). However, the potato ring spot virus was more resistant to the effect of whey. We have also received some verbal reports on use of whey for the control of mosaic virus in grapevines in California and Oregon. The advantage in using whey as an antiviral agent is that it is a biological material that eventually will breakdown and provide some nutrients to the host plants as versus leaving a residue to deal with.





Insecticide

There have been some reports on the potential use of whey for the control of thrips. Tollerup and Morse (39) reported on the potential use of whey as a bait for citrus thrips. They combined whey with phloxine B photoactive dye as a commercial control of citrus thrips. We have also received some reports of use of whey in controlling thrips in flowering bulbs on the West Coast.

Other Chemical Uses

In the past, small amounts of whey have been used in emulsion paints, plant-growth stimulants, manufacture of gypsum board, and in adhesives (40). A 1953 U.S. Patent describes a process of manufacture of an adhesive by neutralizing and evaporating whey to 1/5th its weight and mixing with dextrine at a ratio of 2:1 (41). Whey has also been used as a substrate for production of morel mushroom mycelium (42). Whey was partially deproteinized, neutralized, and supplemented with 1% peptone and 0.5% yeast extract. During a 25-day growth period at 25-28°C, the lactose content of whey was reduced from 5.0 to 0.4% and a biomass yield of 23-25 grams/liter of whey was obtained.

Fertilizer

Landspreading

For many years, excess whey and whey permeate from the commercial cheese plants have been used as a source of plant nutrients for agricultural crops. In the 1960s, University of Wisconsin researchers (43, 44) conducted extensive research on the effects of whey on soil properties and plant growth. They found that whey improved soil aggregation and increased corn yields the first and second year after application. Typical nutrient analysis for whey is shown in Table 1.

Table 1. Nutrient analysis for typical whey.

Nutrient	lb. per 100 gal of whey
Nitrogen (N)	1.22
Phosphorus (P)	0.40
Potassium (K)	1.46
Calcium (Ca)	0.29
Magnesium (Mg)	0.05
Sodium (Na)	0.42
Chlorine (Cl)	1.00

Source: (45)

In 1981, Kelling and Peterson (45) reported a set of guidelines for application of whey to agricultural land. They emphasized the need to adjust application rates to the nitrogen needs of the crop grown. Their recommended application rates were subsequently accepted by the Wisconsin Department of Natural Resources (DNR) as maximum application rates for whey as outlined in NR 214 (46). However, in 1990 a new limitation in the revised NR 214 indicated that the total pounds of chloride applied in the form of whey or whey permeate must not exceed 170 pounds per acre

per year. This new chloride limitation significantly impacted landspreading rates for both whey and whey permeate. No longer was nitrogen the nutrient controlling application rates for whey but rather chloride was the controlling nutrient for whey and whey permeate application rates. A revised set of guidelines for landspreading whey and whey permeate was reported in a UW Dairy Alert (47). (A copy of the "Revised guidelines for landspreading whey and whey permeate" is available on the Wisconsin Center for Dairy Research website at: http://www.cdr.wisc.edu/pdf/dairy_alert/da_landspread_whey.pdf). Some basic guidelines (45) for land application of whey to agricultural land are:

- Apply at rates consistent with nitrogen needs of the crop to be grown.
- Apply individual applications at rates which keep the soil from becoming anaerobic – usually less than 10,000 gal/acre.
- Do not apply where the risk of groundwater or surface water contamination is high.
- Eliminate salt effect on germination by applying according to nitrogen needs and delaying planting for 1 week or more after whey application.
- Since whey is a complete fertilizer similar to animal manure, it should be applied to the same crops to which manure is applied

Summary

The previous pages have listed many potential uses for whey. These range from food applications where additional revenue may be gained from the whey components to land application to dispose of the whey components in an environmentally sound manner. The farmstead cheesemaker must have plans in place, at the time of cheesemaking, as to the utilization of whey components in the fresh state.

Whey is a food substance and should be handled as such since it is very susceptible to fermentation and biological deterioration with undesirable end products. Whether the whey is to be used as fertilizer, feed, or food components, the cheesemaker should have a good whey management program in place to recover as much potential value from whey components, as possible.



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Published by the:

Wisconsin Department of Agriculture,
Trade and Consumer Protection

With support of the following partners:

The Center for Dairy Research,
University of Wisconsin-Madison

The Dairy Business Innovation Center

