

By-Product Use in California Dairy Feed Has Vital Sustainability Implications

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Milk cow feed rations in California include a huge variety of by-product feeds that contribute a substantial share of nutrition. By-product use helps moderate feed costs, provides important income to by-product suppliers, frees Central Valley crop farm resources (land and water) for other uses, and reduces environmental consequences of waste.



Based on a 2019 survey of California dairies, 95% of San Joaquin Valley respondents fed by-products in their rations.

Photo Credit: Karen Higgins, UC Davis

Dairy farms everywhere seek economically feasible and nutritionally adequate feed rations for their cows. Feed for cows and heifers represents more than half of the cost of milk. Therefore, how dairies meet these feed challenges determines, to a large extent, the economic, social, and environmental sustainability of the dairy industry.

Processing and distribution of agricultural raw materials generate by-products that may be used as feeds. This article summarizes the current situation for the use of by-products as feed ingredients in the rations of dairy cows and heifers in California. A “by-product” is the residual material, of plant or animal origin,

produced during the harvest or manufacturing process of a primary product. For example, feeds such as soybean meal or canola meal are considered feed by-products where the primary product is vegetable oil. Corn distillers’ grains and corn gluten feed are by-products of corn processing for the primary products—corn sweetener and ethanol. Cotton seed and almond hulls are important by-product feeds that are from California-grown raw materials.

We show that feeding by-products, including many that are produced near California dairies, is a major feature of the California dairy farm rations and plays a significant role in processing and distribution for many California crops. We also show that, absent dairy by-product feeds, much more land and water resources would be dedicated to dairy feed production and that much more by-product biomass would enter the waste stream, generating troublesome environmental consequences.

Background

Most milk cows in California are in the San Joaquin Valley, surrounded by millions of acres of fruits, nuts, vegetables, and cotton, as well as the processing and distribution facilities that handle these crops. The wide variety of crops that generate potentially useful by-products has facilitated extensive use in feed rations, especially by the dairy industry.

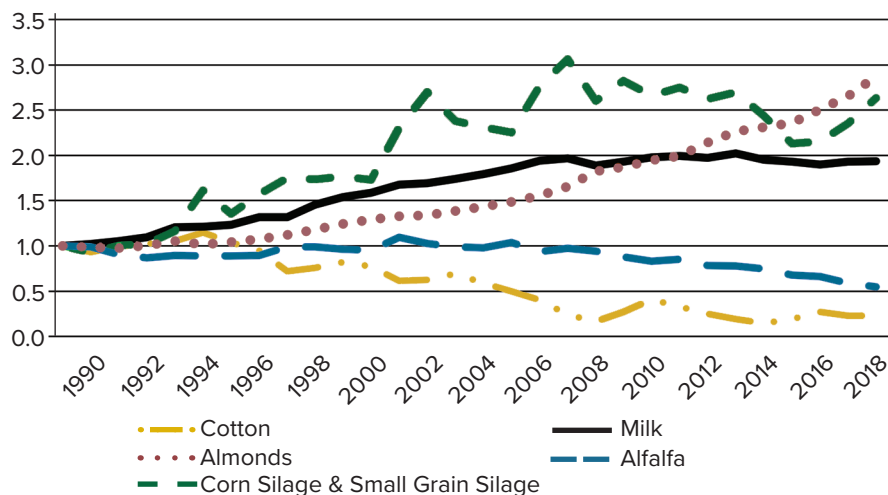
Dairy farming is the largest farm industry in California measured by farm revenue, which has averaged about \$7 billion in recent years. The California dairy herd is the largest in the U.S., with approximately 1.7

million dairy cows, plus replacement heifers. About 90% of cows are on farms in the Central Valley, kept in freestall barns or open lots year-round, and fed a ration of forages, cereal grains, by-product feeds, and supplements. There is very little grazing except for the 4% of cows in the organic segment, mostly in the North Coast region, where cows get a portion of their forage from pasture as required by federal regulations. California dairy is closely linked to other parts of agriculture and the California economy because much of the feed is local, and almost all the processing of California milk is local as well.

The rations fed to milk cows balance the nutrition needed to achieve a target milk production, with continued cow health, and cost. As the relative price of milk to feed falls, cows are fed more inexpensively, and milk production falls. As cow genetics, price and availability of feeds, and the price of milk change, the rations change as well. For milk cows in California, grains and oilseed meals, which supply energy and protein, are typically shipped in from the Midwest States, Plains States, and the Prairie Provinces. Local corn and other grain silages supply energy and roughage, and western alfalfa hay supplies energy, roughage, and substantial protein.

Figure 1 shows the steady growth in California milk production from 1990 through about 2007 and no growth since then. At the same time, almond area grew more slowly than milk production through about 2012. However, since then, almond area has grown by 50%, while milk production stagnated. California silage area tripled from

Figure 1. California Milk Production, and Area of Almonds, Cotton, Alfalfa Hay, and Silage (All Shown Relative to 1990)



Source: USDA, NASS.

1990 to 2008, but then lost a third of that growth by 2017 before beginning to rise again. Meanwhile, cotton area declined by more than 80% by 2009 and has been steady since, while alfalfa area was steady until 2008 and declined by half since then.

Figure 1 documents that in 2019 milk production had become double what it was 30 years ago, while alfalfa area, much of which is used to feed California cows, had fallen by half. Silage area expanded to supply feed for the milk production growth for the first two decades of the period, but has fallen over the past decade. As we shall see below, almond hulls have increasingly become a vital feed

source, just as dairies provide a vital outlet for the ever-expanding quantity of hulls.

By-Product Feeds in the California Dairy Rations

Overall, we find more than 70 distinct by-product feeds used on California dairy farms. Table 1 reports some of the California-produced by-products reported in our 2019 survey of California dairies, a follow-up with ten case study farms in the San Joaquin Valley, and California Department of Food and Agriculture (CDFA) information from 2017. Most products, and most tons of by-products, are California-produced. Some notable by-products

that are shipped into California are canola meal, soybean meal, soy hulls, and dry by-products of the corn ethanol and high-fructose corn syrup industries.

The Table 1 list gives a sense of the wide range of sources. For example, rice and wheat straw are derived from farm harvesting processes. Others, such as citrus pulp, tomato pomace, and bakery waste, are derived from food manufacturing, and finally, some, such as asparagus and kiwis, are vegetables and fruits diverted from human consumption. Not all by-products are plant-based. For example, whey, an important by-product from cheese production, generally enters the human food market, but some is returned to dairies to be used as feed. Some by-products, like dried poultry litter, can only be fed to heifers, and some vegetables, like onions, are only fed to heifers and dry cows to avoid milk taint.

The share of feed costs in milk production varies depending on relative prices from about 50% to 60%. Based on CDFA data for California dairies overall for heifer, dry cows, and lactating cows combined, by-products represent about 35% of feed costs and about 35% of total dry matter fed. Based on our 2019 survey of California dairies, 95% of San Joaquin Valley respondents fed by-products in their rations.

The CDFA gathered extensive cost of production information, including detailed feed rations from more than 100 dairy farms. Almond hulls, canola meal, cottonseed, and distillers' grains were the major by-product feeds as measured by the share of dry matter in a ration. Canola meal accounts for 8% of feed costs, with cottonseed and almond hulls accounting for about 6% and 3.5%, respectively. Distillers' grains, dry and wet, account for another 4.5% of ration cost. More than 65 other by-products together account

Table 1. California-Produced By-Product Feeds and Categories

Almond hulls	Citrus, pulp and dried	Onions
Almond shells	Cottonseed,	Pomegranates
Almond skins and meal	Cottonseed meal	Raisin tailings
Apple and apple pomace	Distillers' grains, wet	Rice bran
Asparagus	Distillers' syrup	Straw, rice
Bakery waste	Fats, vegetable and animal	Straw, wheat and other grain
Beet pulp and molasses	Fish meal	Sunflower meal
Bloodmeal	Garlic	Sweet potato
Brewers' grains and yeast	Grain screenings	Tomatoes and pomace
Cabbage	Grape pomace	Whey
Carrots and carrot pulp	Kiwis	Wheat middlings
Chaff hay	Nutmeal	Vegetable juice pulp
Cherries		

Source: 2019 Survey and Case Study, and 2017 CDFA dairy cost of milk production data.

for another 13% of feed costs. Scaling up to statewide totals, these CDFA data indicate that in California in 2017, about 5.5 million tons (on a dry matter basis) of by-product feeds were included in rations for lactating and dry cows.

Table 2 shows the nutritional content of major California-produced by-products in dairy rations. Overall, California by-products supply about two-thirds of the total by-product dry matter and similar shares of total digestible nutrients. California-produced by-products supply almost one-quarter (0.67 X 0.35) of the dry matter of California dairy rations.

The San Joaquin Valley is home to about 1.5 million dairy cows and large crop production, processing, and food manufacturing industries. Low transport costs for by-products are especially important for moist, perishable by-products, which may be consumed on the same day as delivery, without further treatment to preserve the feed. For many California-produced by-products, limited alternative markets exist without further processing and transportation. When no alternative market exists, the by-product is destined for waste in the absence of a local dairy market.

Almonds represent the largest crop industry, by acreage and value, in the Central Valley and are a major economic contributor. Roughly 95% of the 2.55 million tons of almond hulls produced are used as dairy feed. As the almond industry has expanded, the quantity of hulls fed has likewise grown. Producers of almonds received a price of \$4,860/ton for kernels in 2019 and \$121/ton for hulls. With 2 pounds of hulls produced for every pound of kernels, hulls generate about 5% of the almond industry's revenue.

After decades of decline, cotton production has stabilized in California. About 290,000 tons of cottonseed were

	Dry Matter	Total Digestible Nutrients	Crude Protein
	(Million tons)		
Almond hulls	2.11	1.23	0.14
Corn distillers' grains*	0.53	0.42	0.16
Grape pomace**	0.30	0.10	0.04
Cottonseed and meal	0.23	0.18	0.06
Whey	0.22	0.18	0.03
Straw***	0.17	0.08	0.01
Brewers' spent grains	0.05	0.04	0.01

Notes: * Most of the corn distillers' grains are shipped into California. Shown here is 2019 California production, which is all wet distillers' grains. Production in 2020 has averaged half of 2019 production. California distilleries mostly use corn that is shipped into California.
 ** About 500 thousand tons of additional cottonseed is shipped in to California.
 ***Dry matter, total digestible nutrients, and crude protein analysis based on wheat straw

Source: Calculations based on 2019 author Survey and Case Study and 2017 CDFA dairy cost of milk production data.

produced in California in 2019. About 65% of cottonseed is sold whole from the cotton ginners to Californian dairy farms. Cottonseed is a high-protein, high-energy feed that is fed with no additional processing. About 30% of cottonseed is crushed for oil and meal, and the remaining portion, less than 5%, is used as planting seed. We expect almost all cottonseed meal produced in California is sold to dairies. Cottonseed generates about 20% of cotton production revenue and cotton lint the other 80%.

Grape pomace, the mixture of seeds, stems, and skins produced after crushing, is an important by-product feed. In 2019, 4.11 million tons of grapes were crushed in California. Grape pomace accounts for about 25% of the fresh weight of grapes. For large San Joaquin Valley wineries, we estimate, based on industry interviews, that 90–95% of pomace is sold wet as dairy cattle feed. Dried grape pomace has a national market as feed. Composting of grape pomace is an option, whereas some pomace in Napa and Sonoma counties may be sent to landfills. During peak supply, wineries pay \$10/ton for the collection of pomace, while at other times, wineries receive \$15/ton for pomace that is stored and collected off-season.

If California By-Product Feed Supply Was Reduced

Based on nutritional requirements and costs of by-products and substitute feeds, we estimate that if no by-products were available, average ration costs would rise by about 20%. The implication is about 10% higher production costs and therefore less milk production in California. With no by-products, rations would include more alfalfa hay and corn grain, but less corn silage. We estimate that in this extreme scenario, 1 million acres and 4 million acre-feet of water would be required for new alfalfa hay production. In addition, 4 million more tons of corn grain would need to be shipped into California.

Reduction in supply of by-products could occur if processing industries faced regulations that caused the cost of processing and transporting by-products to rise or if the local processing industries declined. Alternatively, an increase of other demands could make by-products non-competitive as dairy feeds.

Most by-products are individually a small share of dairy rations. Therefore, if a single by-product became unavailable, there would be little change in dairy economics or resource use statewide. Some individual by-products,

such as brewers' spent grains, may have important impacts locally.

A few by-products have important statewide impacts individually. For example, given an elastic long-run demand for California dairy products, we project that removing availability of almond hulls would reduce milk production in California by more than 2% because hulls alone comprise almost 3% of dairy production costs.

Increased quantities of other feeds would be used to replace the nutritional contribution of almond hulls in dairy rations. Corn silage is the forage that would likely replace almond hulls in the ration. To replace the total digestible nutrients lost from almond hulls with corn silage, grown in the San Joaquin Valley, an additional 181,000 acres and 665,000 acre-feet of irrigation water would be required. The implied increase is about 44% of the current allocation of land and water to corn silage production.

If Dairies Cut Back in Demand for California-Produced By-Products

For most processing industries, revenue from the by-product is such a small factor in the economics of the industry that reducing demand from dairies causes only small economic changes. For example, revenue from sales of brewers' spent grains is a negligible share of the revenue of the beer industry. However, loss of dairies as an outlet may have important environmental consequences as breweries struggle to find alternative places to dispose 55,000 tons (on a dry matter basis) of spent grains. These spent grains would generate 29,000 metric tons of carbon dioxide equivalent annually upon decomposition in landfills, which is equivalent to the energy use of about 5,000 passenger vehicles.

Because almond hulls account for only 5% of revenue from almond production, direct revenue impact of

less demand for hulls is small. Few alternative markets now exist for almond hulls. However, in 2020, there were indications of potential future demand for pelletized almond hulls in the Chinese feed market.

Since about 20% of cotton revenues are from cottonseed, the economic implications of reduced demand for seed are significant. Given very elastic world demand for California cotton, if demand for cottonseed from California dairies declined, the price of cottonseed would fall, California cotton production would decline, and cotton industry revenue may decline substantially.

Final Remarks

Use of by-product feeds is a crucial component of the sustainability of the California dairy industry. Reduction in access to by-products would raise dairy costs and reduce the economic viability of the industry. A major implication of by-product use is to reduce the environmental and resource pressures on crop land and especially irrigation water in the San Joaquin Valley. Absent access to by-product feeds, more acres of silage and alfalfa hay would cause even more stress on these limited resources, especially groundwater. Finally, if California dairies were not available to make use of by-products, more would end up as waste. These biological materials would have environmental consequences of local and statewide importance, including additional methane emissions.

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For additional information, the authors recommend:

Hart, Jarrett D., Scott Somerville, and Daniel A. Sumner. 2000. "Economic, Resource, and Environmental Consequences of Changes in Spent Grains Use by California Dairies." Working paper currently under review.

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