New Industrial Uses of Dairy Products

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Milk, as it comes from the cow or is delivered from the farm, represents a complex mixture of ingredients and biochemicals which, if separated and/or modified, have chemical properties and functional attributes that lend themselves to a wide array of nonfood applications.

In many respects, raw milk from the cow is analogous to crude oil that is extracted from the earth, cracked, and separated into vinyls, acrylics, gasoline, motor oil, grease, and other fractions that can be further processed and used as components in any number of consumer goods. Petroleum is today more than just a source of energy to power an engine. It is a feedstock (raw material) used to make literally thousands of products that touch

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almost every facet of our lives. The same is possible with milk. Unlike our knowledge about petroleum, however, our understanding of the full potential of nonfood uses of the ingredients in milk is still in its infancy.

The list of nonfood uses of the components of milk that have already proved to be both technically achievable *and* commercially feasible is long and varied. The potential would appear almost endless, constrained only by the limits of our imagination, the availability of resources to explore and develop them, and the economic reality of exploiting them.

Continued efforts to identify and develop nonfood uses for all agricultural commodities are critical. As non- or less-renewable natural resources become increasingly scarce, the need to define agricultural products as substitutes for these resources becomes even more important. The need to invest in developing these technologies today is critical because of the lengthy time typically required to deliver an innovation to the marketplace economically.

The next few pages suggest just a few of the many possible nonfood uses for each component in milk. Milk and other dairy products are complex mixtures of biochemicals, minerals, water, and combinations of these compounds. The biochemicals in dairy products can generally be classified as carbohydrates, proteins, and fats. Nonfood uses of compounds derived from each of these three biochemical fractions are already products of commerce and the list of such applications continues to grow.

Carbohydrates

The major carbohydrate found in milk is lactose, or milk sugar. Considered a simple carbohydrate, lactose is similar to table sugar in chemical composition but is much less sweet. For some time, and to some extent even today, lactose has been considered a byproduct or potential waste product from the processing of many dairy items such as cheese. Exploration of nontraditional commercial uses of lactose was hampered by the low cost of sugar, which could often be substituted for lactose in many of its more novel applications as a potentially useful surplus commodity.

However, lactose has for many years been used by the pharmaceuticals industry as an excipient and diluent for drugs. Often, the active ingredients in pharmaceuticals, the actual medications, cannot be used in their pure forms. In addition, drugs must be released under proper conditions and over a regulated time period to have their greatest effect. Similarly, the effective dose of a drug is often quite small and sometimes tastes bad. Lactose dilutes the active ingredient in a medication to help ensure that a uniform dose is being ingested, and that the medication is delivered in a form that is convenient and agreeable (in size, shape, and taste) for the user. It also establishes the appropriate conditions and time-release qualities to make medication as effective as possible.

Lactose is also split into its constituent simple sugars, glucose and galactose, which may be further biologically or chemically modified to form

alcohols, lactic or acetic acids, or more complex products such as penicillin. In these applications, lactose must compete with the less expensive sugars and starches that become the commercially preferable feedstocks. However, the economics of these relationships often change, leaving such uses as potential future opportunities. (One is reminded of the increase in the use of ethanol in motor fuels as the cost of petroleum soared during the 1970's.) The alcohol and aldehyde derivatives of lactose appear to offer great promise for commercial application in the chemical industry, where the competition is less plentiful and the finished-product cost higher.

Chemical derivatives of lactose, the lacticol esters (the alcohol form of lactose to which a fatty acid has been attached), are known to have potential as surface active agents and emulsifiers. These fatty acid derivatives of lactose can be used in toothpaste and other toiletries because they are derived from natural ingredients and tend to be nontoxic. Their use has also been demonstrated as quenching agents in the hardening of steel.

Lacticol has been used as a raw material for the production of polyurethane foams. These foams have demonstrated their effectiveness as home insulating material as well as for use in packaging. Lacticol has also demonstrated potential in the manufacture of urea formaldehyde resin adhesives. This compound has even been dried and pressed into briquettes for use as fireplace logs. The commercial viability of these applications is again limited by the relative cost of lactose compared to other agricultural sources of fibers, starches, and sugars.

Proteins

Although the current and potential uses of the carbohydrates in milk are numerous, the potential commercial nonfood applications of the protein components in milk appear to be even greater. The ability of dairy proteins to act as surfactants and to stabilize emulsions has been demonstrated in a wide array of food applications. In addition, these properties of proteins are beginning to find application in nonfood systems such as personal hygiene and cosmetic products.

A new vista of future nonfood applications for dairy proteins follows the recent discovery indicating that microparticulation (the physical splitting of large particles of proteins into small ones) of dairy proteins creates a variety of novel textural and functional attributes previously unseen in protein. Microparticulation of dairy protein is currently being used in producing replacements for fat in foods. The potential of this technology in nonfood systems is just now beginning to be explored.

Casein, the protein found in greatest quantity in milk, has had nonfood commercial applications for some time. It has been used in specialty adhesives, premium paper coatings, the manufacture of biodegradable plastics, and even material that substitutes for ivory. Recently, special "high-clarity" casein has been used in the manufacture of television screens. In a similar capacity, it is currently being used as a component

of the light-sensitive emulsion on some photographic film.

Within the past 3 years, scientists have demonstrated that casein, as well as the whey proteins in milk, can be made into a clear filmlike packaging material. Unlike traditional packaging films, those made from milk proteins are both edible and readily biodegradable. Possessing many of the properties of conventional packaging materials, the results of this technology appear to have great potential for use in both the food and pharmaceuticals industries, where the unique edible property can be especially useful. Perhaps one day in the near future, home cooks will be able to spray a freshly cut onion or block of cheese with an edible protein film before returning it to the refrigerator and, several days later, use it with the assurance that it has not lost its taste or nutritional quality.

Since the beginning of time, milk from mammals has provided their newborn not just with the nourishment of its food value, but also with some protection from infectious disease because of the antibodies (immunoglobulins) it contains, especially in the early days of lactation. The transfer of immunological protection has been recognized as an essential feature in the synthesis of formulas for newborn calves. It has also been recognized that the lactating cow is a potential source of large quantities of antibodies for use against a host of animal diseases and possibly some diseases of humans. Today, lactating cows are being used to produce antibodies that are subsequently harvested and used as antibiotic preparations for the treatment of many animal diseases. Cows have become potential factories for producing pharmaceuticals used in veterinary medicine.

It may be feasible to transfer this technology to applications in human disease. The antimicrobial properties of dairy proteins might also be used in other consumer product applications such as personal hygiene products and cosmetics.

In laboratory tests, derivatives of many dairy proteins—either existing in raw milk, developed during natural fermentation processes, or created by *in vitro* hydrolysis—exert a number of biological effects, such as blood pressure regulation. The potential of these substances to be useful pharmacological agents for humans is being studied in several laboratories in this country as well as abroad.

Milk is also a source of lesser amounts of many other protein components that may have commercial potential for the pharmaceuticals and personal health care product industries. Proteins such as lactoferrin (an iron-building protein) and several enzymes (such as lactoperoxidase) have been studied for their potential application in these industries, but much remains to be accomplished in developing this technology.

Fats

The potential nonfood uses of components of the fat, or lipid, portion of milk are less well defined at this time but are nonetheless sizeable. Use of dairy lipid derivatives as industrial lubricants has been demonstrated, but

their use is currently constrained by less expensive alternatives. Dairy lipids may also be converted to waxlike substances for use as water repellants. Derivatives of fats found in milk have also been shown to have potential as emulsifiers, surfactants, and gels. The nonfood applications of these properties are only now being explored. Other lipids derived from milk have been reported to have antioxidant, antimicrobial, and antitumor properties, each of which holds promise for commercialization in the pharmaceuticals industry. The use of dairy fat as a feedstock for producing biomass for animal feeds or energy production has been proposed. At present, such proposals are not cost-effective.

Conclusion

This chapter is intended to provide merely a brief "look under the tent" at the promising current and future nonfood uses of some of the ingredients in milk. Much research is under way to expand on some of the applications noted above, as well as to identify new nonfood uses of these and other components in milk and other dairy items. As the supplies of less-renewable natural resources begin to shrink and the economics of many of the identified applications shift to support their further development, many of the more innovative potential uses of dairy ingredients may come into commercial use. ❑

26 New Technology for Animal Hides, Wool, and Cotton

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When we think of nonfood agricultural commodities produced in this country, cotton surely comes to mind as a source of fiber for clothes. Nevertheless, two major byproducts of the meat industry are also major sources of nonfood products for apparel: sheep give us wool, and the hides of sheep, pigs, and cattle give us leather.

You might guess correctly that cotton is overwhelmingly the most significant natural fiber crop in this country. We meet all our national needs for the raw fiber from the domestic crop. Even when cotton in finished products is included, we are a net exporter as well. The scope of USDA-ARS cotton research covers the full breadth of the cotton industry, including such diverse areas as cotton