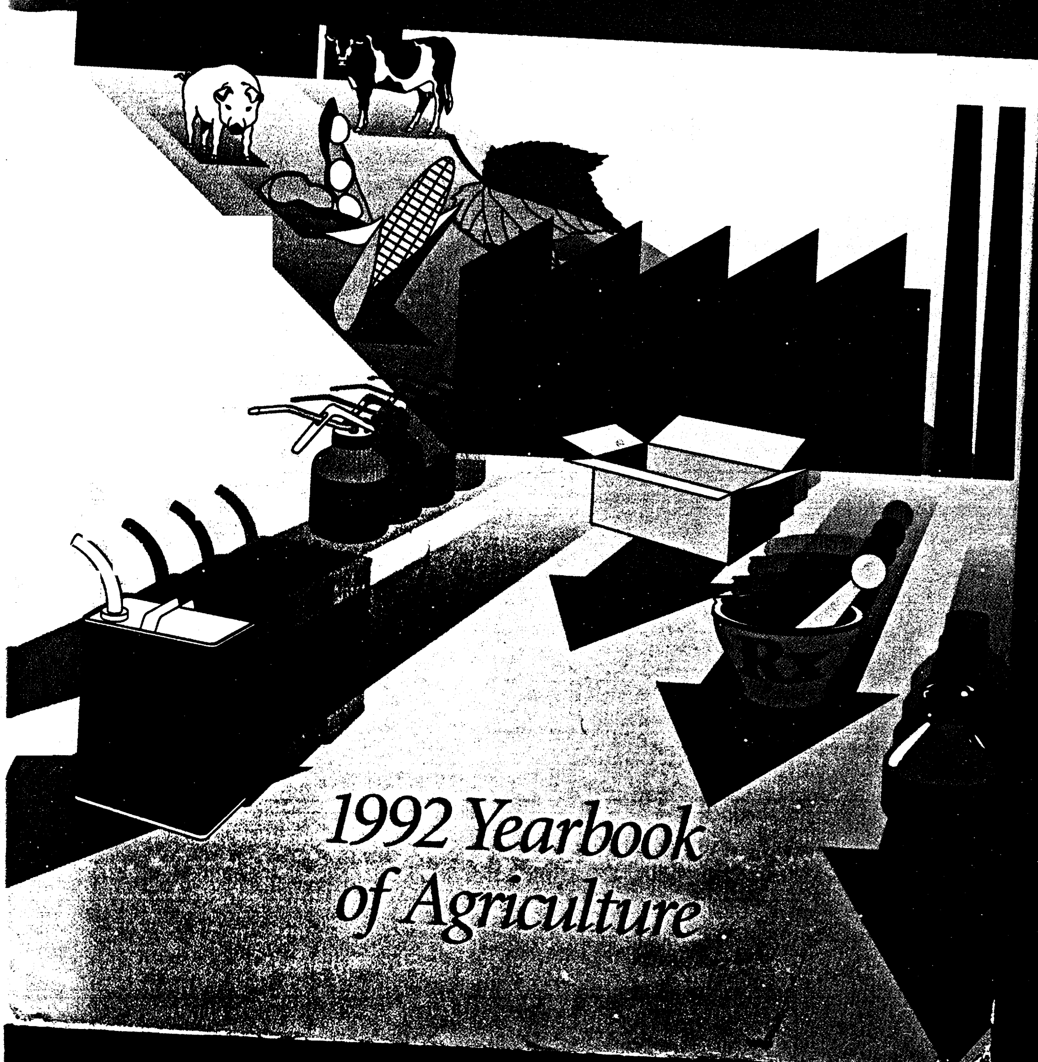
New Crops New Uses New Markets



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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 growth, ginning, marketing, spinning and weaving, and textile finishing. Much of the program has been centered at the Southern Regional Research Center (SRRC) of the Agricultural Research Service (ARS) in New Orleans.

In terms of wool, we meet a third of our needs for raw wool fiber from the domestic clip, but when wool in imported garments is factored in, that figure drops to 13 percent. Australia and New Zealand, the world's major exporters of wool, raise their sheep primarily for fiber. American wool, on the other hand, is truly a byproduct of the lamb industry. The current ARS program in wool research is a small one, functioning out of the ARS Eastern Regional Research Center (ERRC) in Philadelphia. The aim of the current program is to add value to the domestic wool clip, which suffers in its market return relative to its foreign counterparts.

Regarding hides and leather, the United States produces more animal hides than its tanning industry can convert to leather, so our hide *export* market is a $2 billion-a-year industry. We are also net exporters of unfabricated leather, but when shoes and other fabricated products are factored in, we are overwhelmed by imports. ARS research in hides and leather is also centered at ERRC and focuses on all aspects of research, from hide quality and preservation through tanning and finishing.

This chapter concentrates on some new technological developments from all of these ARS programs. Research is directed toward making quality products, making the domestic products more competitive with their foreign counterparts, making our products more durable and easy to care for, and assisting the producers and users of these commodities in working within increasingly stringent environmental controls.

Wool: Bleaching Stained Fibers and Black Hairs

Raw wool carries with it such a tremendous amount of extraneous material that the true wool yield may be only half the original weight of the fleece. Most of the contaminants, such as grease, are washed out during "scouring." However, two contaminants particularly problematic in some domestic wools are stubbornly persistent—heavily stained fibers and black hairs. Stained fibers give wool a yellow cast that is particularly noticeable when the end product is a white or pastel-dyed garment. As for black hair, just a few enmeshed in the thousands of white fibers in a piece of fabric are amazingly conspicuous.

Stained fibers are traditionally bleached with hydrogen peroxide, an oxidative bleach. Once oxidative bleaching is done, it may be followed with reductive bleaching (another class of bleaching agent) to achieve the whitest products. Such combined or "full" bleaching is an expensive process because it involves the preparation and heating of two separate bleach baths and the rinsing of the product in between. In general, full bleaching is not practiced.

ARS scientists in Philadelphia looked at full bleaching and discovered that the two processes could be combined into one sequential procedure in the same bath. In the new process, the two parts are accomplished in a clever way by chemical manipulation of the peroxide left over after the initial oxidative bleaching. Instead of discarding that bath, the peroxide is chemically converted to a reductive bleach by addition of thiourea to the bath. The result is extra whiteness.

Bleaching black hairs and stained fibers simultaneously is particularly difficult. The textile industry uses a variation of peroxide bleaching that requires—specifically for the black hairs—treatment of the wool with iron salts. When the new ARS process is coupled with the iron-salt method, the elimination of the rusty discoloration that sometimes results from residual iron is an added benefit.

Followup work is now permitting the single-bath full-bleaching concept to be extended to allow subsequent dyeing in the same bath. ARS scientists have been granted four patents to cover the bleaching process in all its variations. These scientists have worked to transfer this technology to the private sector by assisting woolen mills in experimenting with the system in their plants. One license has already been granted, a partially exclusive license for one niche of the woolen market.

Hides and Leather

Hide Preservation. When a hide comes out of the packing plant, it usually has to be preserved for a long period during shipping to and storage at the tannery. Almost all hides are preserved through curing in a concentrated salt brine. Needless to say, this is a large generator of salt pollution. ARS scientists in Philadelphia have looked at an unconventional way of preserving hides without using salt.

Irradiation by a beam of electrons is currently used to sterilize small items such as surgical bandages and scalpels. It is very effective so long as the item is enclosed in sterilized packaging. In 1986, a number of hides were sealed in plastic with a small amount of bactericide, then irradiated with an electron beam. Some of those hides were soon tanned to leather, and the properties of the resulting leather were compared to those of leather from brine-cured hides. Differences were inconsequential. More impressive, however, was recent experimentation on the remaining hides in which tanning was delayed; *5 years later*, samples were removed from their packaging and tanned to leather of excellent quality. The private sector is showing renewed interest in such preservation, and new research is under way.

Chemist Frank Scholnik (left) and research associate James Chen examine the results of experimental treatments for leather. The Agricultural Research Service has designed an environmentally friendly way to sterilize hides with electron-beam irradiation rather than salt brine curing.
Scott Bauer/USDA 92BW0839

Recycling of Solid Tannery Waste. Tanneries generate a tremendous amount of solid waste during the multistep conversion of hides into leather. Much of this waste is chrome-containing solid waste from the 90 percent of hides that are chrome tanned. This waste, mostly destined for landfills, amounted to over 50,000 metric tons in the United States in 1988 alone.

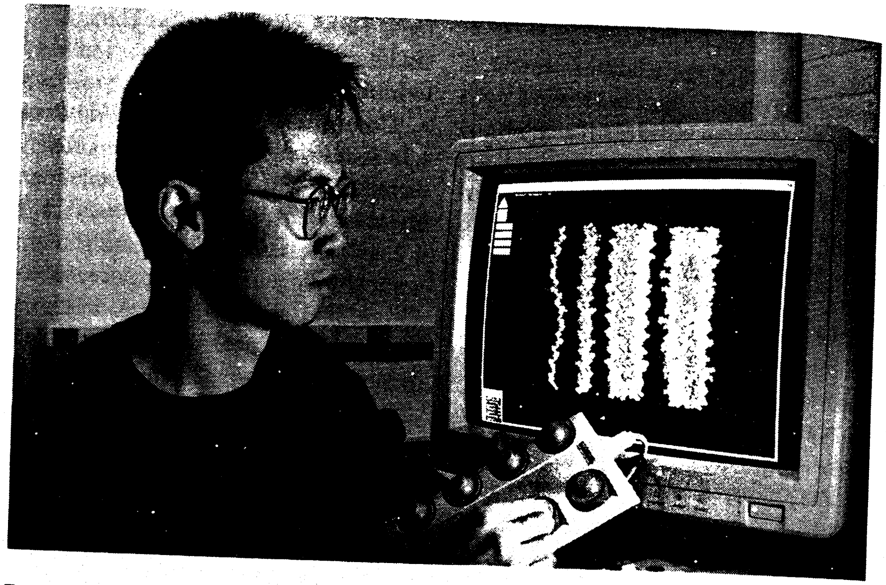
The tanning industry appealed to ARS scientists in Philadelphia to look into chrome waste. Landfill expenses were skyrocketing, and environmental concerns were rising over potential hazards from this waste. Although the chrome in this waste is not the toxic variety and is legal in landfills, questions have been voiced over the long-term fate of the waste in landfills.

ARS responded by developing a process that allows the chrome to be separated from the waste. The recovered chrome can be recycled back into the tanning operations, and the balance of the material, now chrome-free, can be used for fertilizer or as an additive for cosmetic products or animal feed. The ARS process has been patented, and worldwide interest has led to initial licensing activity.

Computer Modeling of Hide Protein (Collagen). Why would such a theoretical item as collagen modeling be included in a chapter on new technology? The computerized molecular model of collagen is being developed and refined, and new changes to the model are continually made available to the world's research community through the Protein Data Bank of the Brookhaven National Laboratory. This ARS model is of immense value, not only for leather research but also for diverse studies of collagen's role in human skin and bone tissue.

A lot of tanning technology has been developed from experience or observation, with no real understanding of why it works. This is particularly true for chrome tanning. Why is chrome tanning so effective? It is because chrome (or its substitutes) interacts with collagen, the backbone molecule for hide tissue. Collagen is a complex molecule that forms bundles seen under the microscope as fibers.

The computer model, a detailed map of every atom of these fibers, will be used to learn how chemicals such as chrome neatly fit into the molecular structure of collagen during tanning. In response to increasing pressure for investigation of "environment-friendly" chrome alternatives, the model will be used to test the ability of chrome substitutes to "dock" with collagen. Followup studies in the lab and tannery will be used to confirm the effectiveness of these chrome alternatives as tanning agents.



Research Associate James Chen studies the stages in which collagen (hide protein) models interact to form larger microfibril units. The computer model is a detailed map of every atom of these fibers. The model will be used to see how chemicals fit into the molecular structure of collagen during tanning.
Scott Bauer/USDA 91BW2138-6

Solvent-Free Finishes for Leather. Did you know that there is a polymeric finish on the surface of most leather? This is particularly obvious in the case of patent leather. Traditionally, finishes are applied to leather by spraying it with materials dissolved in organic solvents. This method is increasingly coming under attack because of the environmental hazards associated with those solvents. Elaborate recovery systems must be used to prevent these solvents from entering the atmosphere.

ARS scientists looked at a solvent-free approach—finishes cured by exposure to ultraviolet (UV) light. UV-cured finishes are used today on many nonleather products (such as metal cans and paper). Over several years, ARS learned how to apply UV-cured finishes to leather while still maintaining the necessary durability and flexibility. UV-curing was found to be applicable to intermediate-and top-coating of leather, including patent leather finishing and color coating. Considerable effort by ARS has brought together the leather industry and suppliers of chemicals and equipment for the UV-curing sector. Commercialization is expected soon, with new interest in the process being shown both in the United States and abroad.

Cotton

Formaldehyde-Free Durable-Press Treatment. Most chemical agents used today to impart easy-care properties to cotton fabrics are derivatives of formaldehyde. These chemicals are inexpensive and are used to produce cotton fabrics that require little or no ironing. However, since regulations of the Occupational Safety and Health Administration mandate low levels of formaldehyde in the workplace, textile mills incur additional expenses related to monitoring formaldehyde in the air and to assuming responsibility for the health of mill workers for an indefinite period of time. Thus there is need for a new type of compound that does not contain formaldehyde or any other substance that might require similar regulation.

ARS scientists in New Orleans have recently used new chemicals to give easy-care properties to cotton fabrics. The most successful of these chemicals is BTCA (butanetetracarboxylic acid). Citric acid, a constituent of oranges, lemons, and other fruits, is also being used. These agents do not contain any known toxic materials, and they give a resilient product that retains more strength than does conventional durable-press cotton. For now, however, they are more expensive than the formaldehyde-containing agents currently in use.

The use of these chemicals has been patented by ARS, and numerous chemical and textile companies have expressed interest in licensing them. Full commercialization will depend on cost-competitiveness and future OSHA regulations regarding formaldehyde. Potential beneficiaries include textile mills that produce durable-press fabrics that contain cotton and their mill and garment workers who would work in a better environment.

Dyeable Durable-Press Fabrics. Cotton fabrics treated for easy care cannot be dyed because the large dye molecules can no longer penetrate into the fabric fibers. For this reason, cotton fabrics are dyed before they are treated chemically to give them easy-care properties. These dyeing treatments are done on the uncut fabric, so colors must be chosen prior to garment manufacture.

Recently, there has been increased interest in dyeing finished garments as a means of reducing inventories of poorly selling colors and of providing a mechanism for quick response to

Colorful, dyeable, wrinkle-free cotton fabrics are examined by chemist Robert Harper, Jr. ARS scientists have developed processes for adding special nontoxic, dye-attracting chemicals to conventional durable-press fabrics.
Perry Rech/USDA 90BW1829-34.

fashion trends. This technique has been limited to garments made from unmodified cotton that would accept the dyes. Such dyeing results in wrinkled garments that are acceptable for some, but not all, markets.

ARS scientists in New Orleans have developed processes for adding special dye-attracting chemicals to conventional durable-press formulations. These chemicals, which contain cationic (positively charged) sites, are permanently incorporated into the durable-press fabric. It is then possible to dye this cationic durable-press fabric with dyes that contain an anionic (negatively charged) site. The most successful additives to date are choline chloride and triethanolamine, nontoxic materials used in chicken feed and cosmetics, respectively. Not only do variations in the way the cationic compound is applied lead to unusual special effects on the fabric, but garments prepared from these cationic easy-care fabrics may be dyed a variety of colors.

This technology has been patented and is available for licensing. Potential beneficiaries include the U.S. textile industry, which would be helped in its struggle with competition from imports, and various small businesses specializing in garment dyeing.

Temperature-Adaptable Fabrics. Cotton fabrics, like most substances, increase in temperature proportional to the amount of heat they experience. ARS scientists in New Orleans, however, now have altered the chemical composition of fabrics so that they do not respond proportionately to the amount of heat applied. Over certain temperature ranges, large amounts of heat are absorbed with little increase in fabric temperature. Upon cooling, this stored heat is released. These heating and cooling cycles are repeatable. Fabrics with this property are described as temperature adaptable.

To obtain this property, the fabric is treated by attaching compounds known as polyethylene glycols to cotton by means of the conventional durable press reagent DMDHEU (dimethyloldihydroxyethyleneurea). The temperature range in which heat is absorbed is controlled by the molecular weight of the polyethylene glycol.

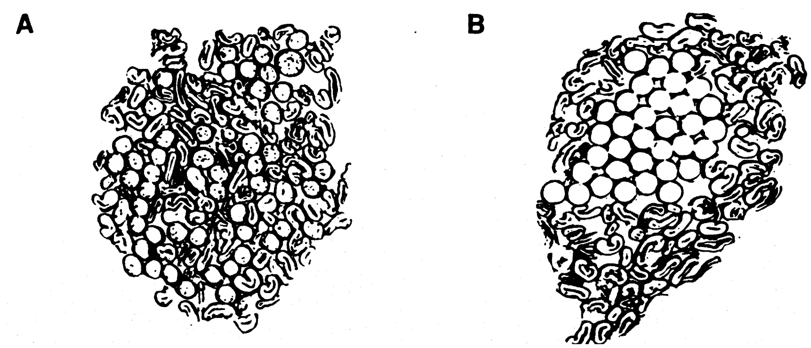
Other beneficial and improved properties resulting from this treatment include resistance to abrasion and pilling (formation of fuzz balls), better oily soils release, decreased static charge, enhanced water absorption, and antibacterial activity.

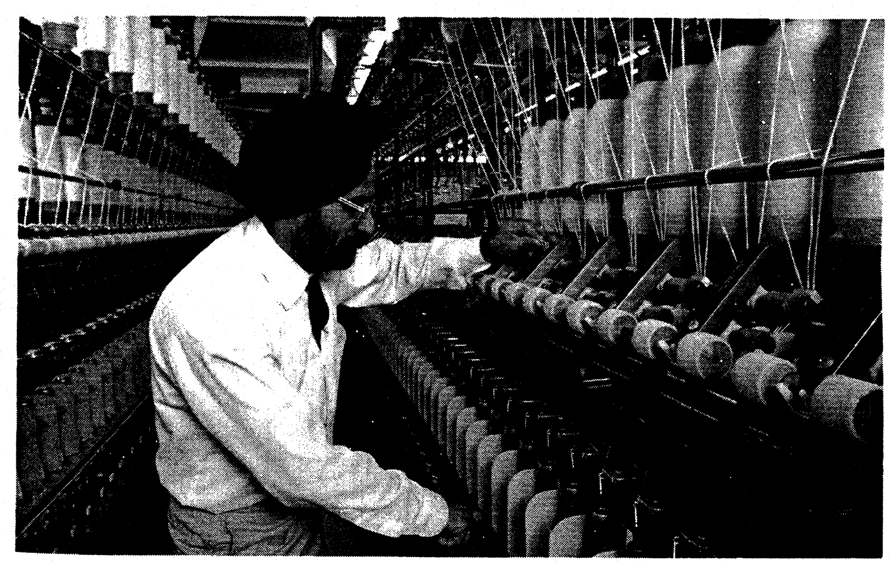
Potential uses for these products are numerous, including clothing designed for both hot and cold climates. This process has been patented and has been licensed for specific uses by two companies to date. It is currently being sold as a component in skiwear and in thermal socks and thermal underwear by the two licensees. Other applications are anticipated.

Staple-Fiber Core Yarns. After numerous launderings, all-cotton fabrics, particularly those chemically modified to be durable press, show obvious damage from abrasion, such as holes at sharp creases. One solution to this problem has been to blend cotton with polyester fibers. The cotton provides the comfort and the polyester the needed strength. These fabrics, known as "intimate blends," have been in use for many years.

Cotton/polyester intimate blends are not free from problems. They are not as comfortable as 100-percent-cotton fabrics and lack some aesthetic properties. On repeated laundering, the blended material forms surface fuzz balls (pill). Also, blended fabrics

Figure 1: Cross sections of intimate-blend (A) and staple-fiber core (B) cotton/polyester yarns.





Cotton technologist A. Paul Sawheny observes the polyester staple-core/cotton-wrap spinning system, a new way to blend more cotton fiber with synthetic fiber. The yarn results in a fabric that is strong, yet comfortable.
Perry Rech/USDA 90BW1812-30

are usually difficult to treat for flame retardancy.

ARS scientists in New Orleans have developed a new type of cotton/polyester yarn that eliminates most of these deficiencies. During spinning of staple-fiber core yarns, the synthetic staple core is twisted while simultaneously being wrapped with cotton. This results in a yarn with a cotton surface and a synthetic interior. A comparison of the cross sections of intimate blend and staple-fiber core yarns is shown in figure 1.

In staple-fiber core yarns the cotton surface has a natural appearance, feels comfortable when worn, is dyeable with cotton dyes, and can be otherwise chemically modified. The synthetic interior provides strength and dimensional stability.

This process has been patented and is licensed to one company. Potential uses include apparel and home furnishing.

Conclusion

Consumers appreciate the properties of goods made from natural materials such as hides, wool, and cotton. At the same time, the public holds the manufacturers of these goods responsible for meeting ever-increasing environmental standards. ARS continues to maintain an awareness of these two needs in its research. ❑

Biotechnology for Tailoring Old Crops to New Uses 27

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The new tools of molecular biology, with their capability for effecting genetic changes that are precise and rapid, can help significantly in the development of new uses for agricultural crops. As used here, the term "biotechnology" refers to these new methods of molecular biology—techniques that use living organisms to make or modify products, to improve plants or animals, or to develop microorganisms for specific uses.

The development of new products from nontraditional plants—such as kenaf, guayule, and crambe—has been proceeding for a number of years. For the most part, these plants have been produced and propagated by traditional methods of natural variation and artificial selection followed by economic assessment. These methods can be both labor-intensive and time-consuming. By comparison, the methods of modern molecular biology offer the prospect of introducing precise,