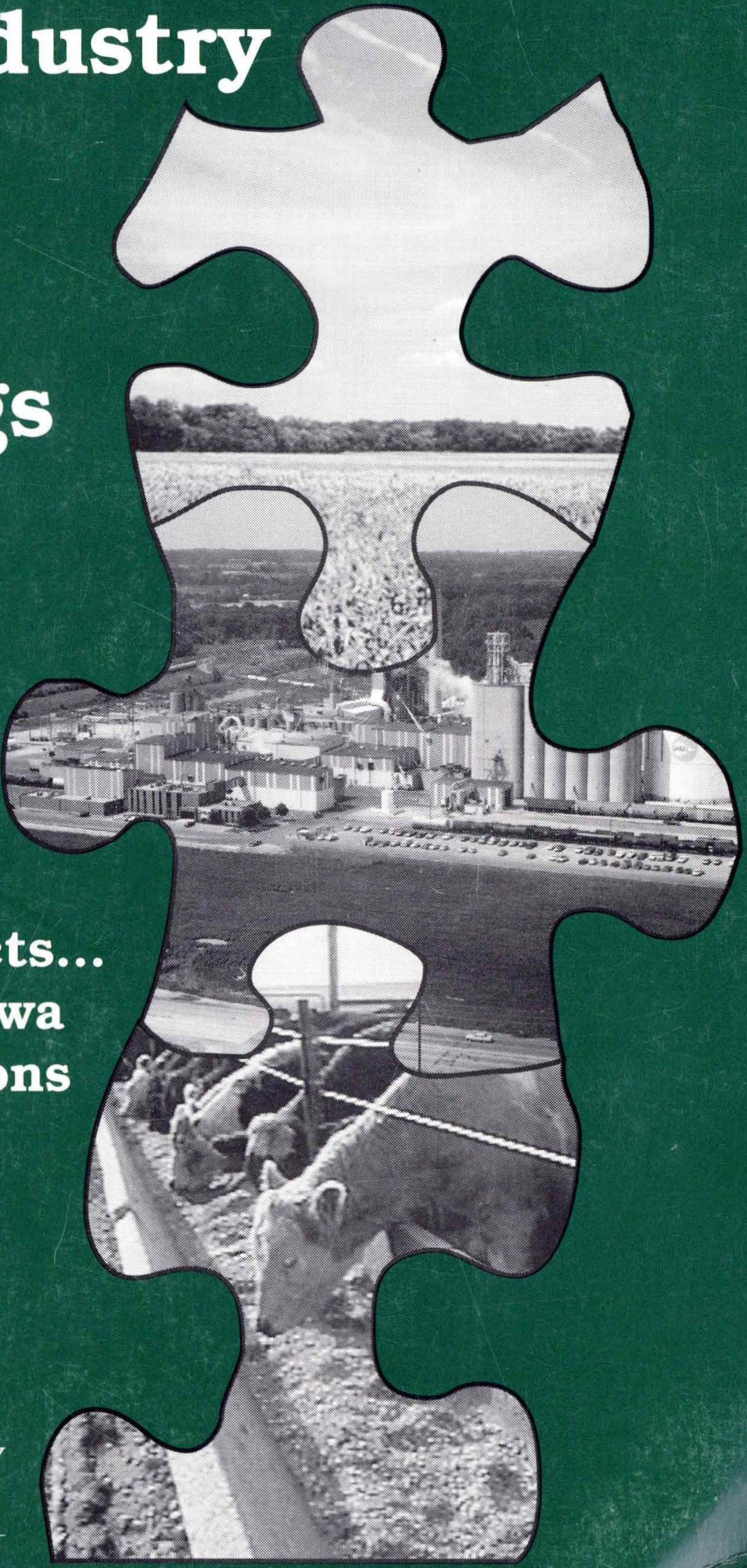
Connecting the pieces of a growing Iowa ethanol industry



Proceedings

March 1995

Ethanol Co-Products... Adding Value to Iowa Livestock Operations

IOWA STATE UNIVERSITY
University Extension
Ames, Iowa

EDC - 28 | May 1995

Acknowledgments

Getting people from three of Iowa's most important industries—grain production, cattle and corn processing—involved in a month-long program does not just happen. To coordinate the ethanol co-products conference and five regional seminars in March, Iowa State University Extension relied on the help of many people.

A central planning committee met months before the conference to iron out the logistics and decide who could best address the issues involved. Sites were selected, regional coordinators named, and local feeders and nutritionists contacted to participate in panel discussions.

From there, word went out through the ISU Extension network and the nine sponsoring groups. The goal was to generate as much grassroots interest as possible—among farmers, livestock feeders, elevator managers, and owners of related businesses. More than 16,000 fliers with information about the programs were distributed to the membership of the sponsoring groups.

Meanwhile, a team of ISU Extension educators and the Iowa Corn Promotion Board went to work on a 15-minute video to be used at each seminar and for future programs. "Corn: Adding Value to Iowa's Future" explains the wet milling and dry milling processes, and what's expected in the future.

The effort attracted more than 400 participants statewide, as well as dozens of people who agreed to serve as speakers and moderators. Although it's impossible to thank every person involved in this project, ISU Extension staff gratefully acknowledges the contributions of the following individuals:

Central planning committee: Gary Alberts, Iowa Institute for Cooperatives; Shannon Fesenmeyer, Agribusiness Association of Iowa; Mary Holz-Clause and Dan Loy, ISU Extension; Joe Jones, Iowa Department of Economic Development; Chad Kleppe, Iowa Soybean Association; Lucy Norton, Iowa Corn Promotion Board; Evan Stadlman, Iowa Corn Growers Association; Pat Paustian, Iowa Department of Agriculture and Land Stewardship; Terry Peter and Steve Stanton, Farm Credit Service; Mark Williams, Iowa Cattlemen's Association, and Rod Williamson, Iowa Corn Promotion Board.

Site coordinators (all from ISU Extension): West Des Moines—Dan Loy and Mary Holz-Clause; Walnut—Darrell Busby; Carroll—Dennis Molitor; Oelwein—Dale Thoresen; Amana—Ron Irvin; and Sheldon—Beth Doran.

Keynote speakers: West Des Moines—Gov. Terry Branstad; Walnut—Iowa Secretary of Agriculture Dale Cochran; Carroll—Robert Pim; Oelwein—Seeley Lodwick; Amana—William Trent; and Sheldon—Phil Dunshee.

Producer and ethanol plant panel participants: West Des Moines—Martin Andersen, Reg Clause, Junior Cooper, John Greig, Bruce Heine, Larry Johnson, and Philip Madson; Walnut—Joe Hoye, Charlie VanMeter and Alan Zellmer; Carroll—Jim Andrew, Roger Nieland, Greg Simons, Norm Soyer, and Charlie VanMeter; Oelwein—Scott McGregor, Steve Recker and Mark Vagts; Amana—Bob Johnson, John McGrath, and Wayne Newton; and Sheldon—Joe Greig, Curtis Jones, and Bernie Punt.

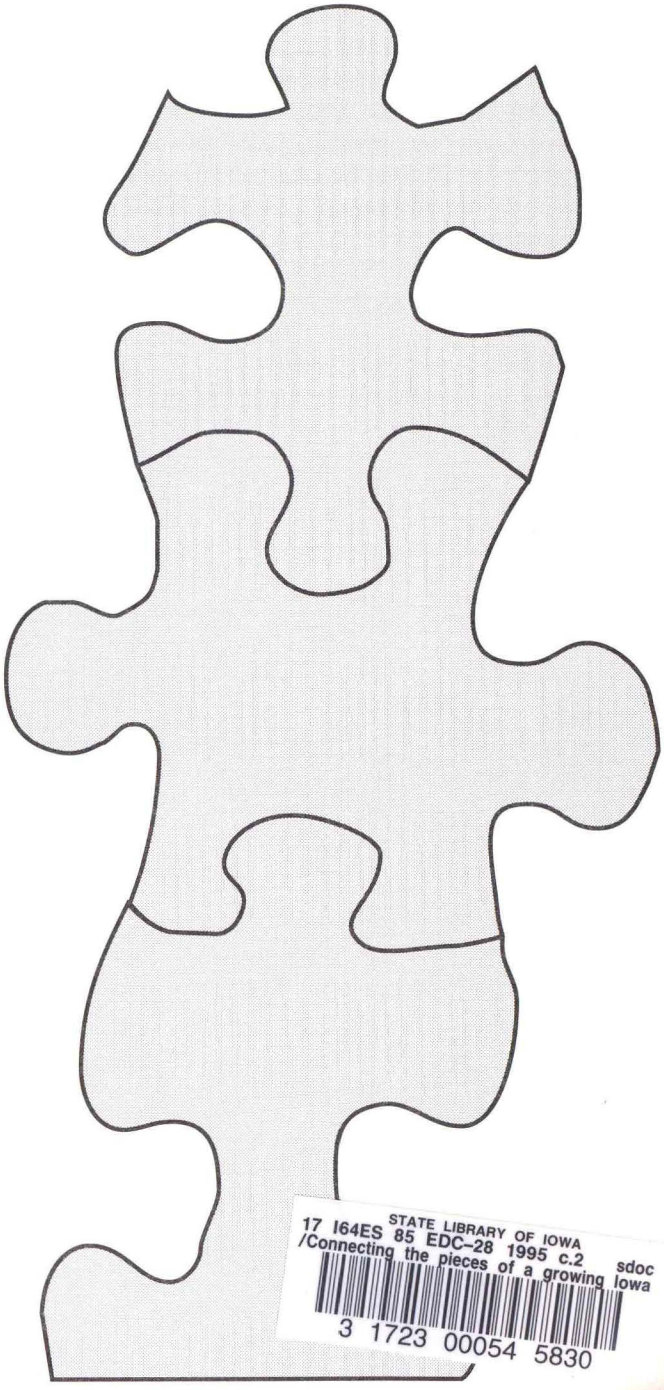
ISU Extension support staff:

Video production—Brian Menz and Roger Brown.

Marketing and proceedings—Elaine Edwards, Laura Miller, Valerie King, Annette Adcock, Doug Cooper, and Jim Trow.

Registration/office—Donna Peters, Sarah Terrones, and Charles Persinger.

Connecting the pieces of a growing Iowa ethanol industry



Proceedings from a one-day conference and five regional seminars

March 7, West Des Moines
March 14, Walnut
March 15, Carroll
March 16, Oelwein
March 21, Amana
March 22, Sheldon

Sponsoring organizations

Iowa State University Extension
Iowa Department of Agriculture and Land Stewardship
Agribusiness Association of Iowa
Farm Credit Services of the Midlands
Iowa Cattlemen's Association
Iowa Corn Growers Association
Iowa Institute for Cooperatives
Iowa Department of Economic Development
Iowa Soybean Association

IOWA STATE UNIVERSITY
University Extension
Ames, Iowa

Dedication

This proceedings is dedicated to all people in the agriculture industry who work incessantly to improve the lives of all farmers. We especially remember Bob Pim, long-time Iowa beef producer and the former director of the USDA Farmers Home Administration, who died in a car accident this spring.

In his keynote address at the Carroll seminar March 15, he issued a challenge for those working to build partnerships in the ethanol, corn production and cattle industries. Here are two ideas he discussed; they come from a 33-point Leadership Challenge used by the manager of a large company to market a new management information system to employees.

- Give attention to restraining forces. You can spot restraining forces: they are generally emotional, negative, social, or psychological, but they are subconscious. On the other hand, driving forces in a project are usually logical, positive, economic and conscious.

  Remember that unexpressed feelings never die; they are only buried alive to rise up again in uglier, more unpredictable ways. It is, therefore, imperative to listen to restraining forces with the intent to understand, not with the intent to reply. Anything else is manipulation. The human capacity to detect insincerity is almost instantaneous, and the result will be cynicism.
- Work in your circle of influence. Influence is like a muscle: it gets stronger with use. If you focus on things within your circle of influence, it will grow larger and gradually more matters will come under your control. Remember that to work effectively, you must value trust and teamwork over politics and power.

These ideas, no doubt, are relevant to issues discussed during these seminars, and Bob Pim certainly used them in his own lifetime. He will be missed by those within his wide circle of influence.

Forward

It's a matter of putting the pieces of the puzzle together. Conference speaker Larry Johnson, Minnesota's "Ethanol Answerman," probably summed it up best when he said:

These days farmers are looking at how to market and add value to their products. They're not just selling raw materials out on the open market anymore.

Corn and cattle production are value-added industries. The farmer and the feeder add value to a product. When corn is processed into ethanol, there are other products besides the clean-burning, renewable fuel expected to be a key component of future fuels. There also are products that, when used locally, may provide the key to success or failure of cooperatively owned, mid-sized ethanol plants. Ethanol co-products, including corn gluten feed, corn gluten meal, and distillers dried grains, are excellent sources of protein, energy, and fiber for livestock.

In other words, the farmer and the feeder need to work together, along with the corn processing industry in Iowa, to add value to two of Iowa's most important agricultural products, cattle and corn.

These programs were funded by a legislative appropriation granted from the Iowa Department of Agriculture and Land Stewardship. Its purpose was to help Iowans explore explore the possibilities—to look at the research, to find out how feeders are using co-products in rations, and to consider other factors at work in Iowa communities.

We are pleased to offer this proceedings, the record of a lively exchange of ideas and information presented at the statewide conference in West Des Moines.

We hope this book can be used as a reference for feeders interested in ethanol co-products, as well as a resource for people interested in value-added industry in Iowa. For those who don't know the difference between dry-milling and wet-milling processes, we turn your attention to page *17* and other facts you might find helpful in this book.

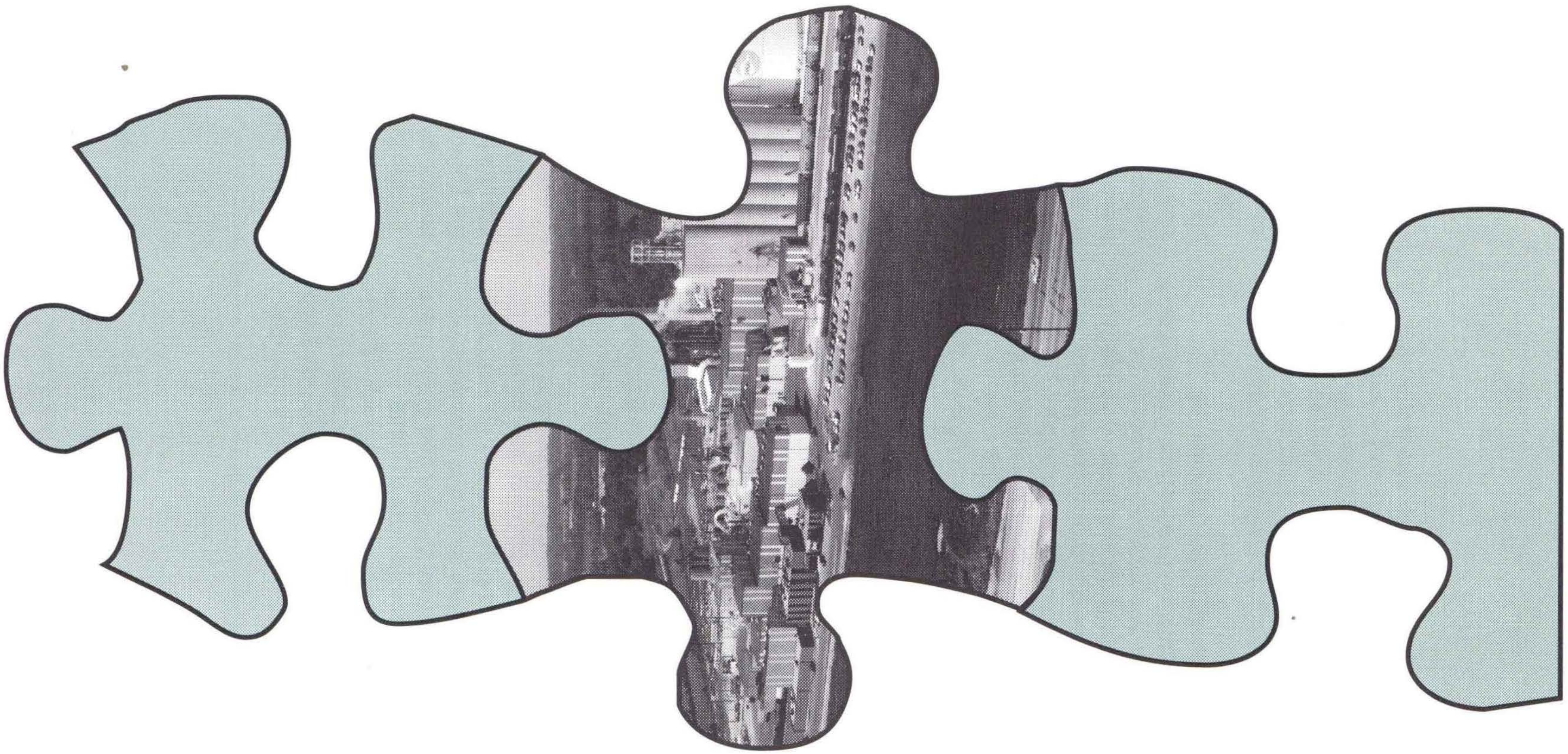
Most of all, we hope what happened at the programs—one-on-one interaction among Iowans of many different interests—helps the puzzle pieces begin to find their place in Iowa.

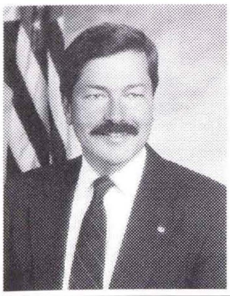
If you find this information helpful, or learned something at the programs, be sure to thank your state representative. Without the legislative grant and the foresight of those who supported and approved it, this effort would not have been possible.

—Mary Holz-Clause and Dan Loy
Ethanol Co-Products Project Coordinators
ISU Extension

Table of Contents

The Ethanol Industry





Value-Added Agriculture in Iowa

Remarks of Iowa Governor Terry E. Branstad

The state of Iowa is blessed with rich and productive farmland and some of the hardest-working people in the world. That combination has made agriculture the foundation of our economy and will help agriculture grow and prosper for decades to come.

Trade agreements such as NAFTA and GATT have opened new doors for Iowa grain and livestock. We are working to take advantage of those opportunities. Iowa quality beef and pork are being sold all over the world. Thousands of Iowans are employed in processing meats.

Value-added agriculture not only creates new markets and demand for corn, soybeans and livestock, it creates jobs in processing and transportation and has a ripple effect throughout the economy.

Most of you have heard of the town of Eddyville in Wapello County. I've been talking about Eddyville for quite some time, but its success story just keeps getting better.

Once a sleepy coal town, Eddyville is now a thriving community with several ethanol and corn-sweetener plants. It uses all of the corn in 10 counties and employs people from miles away.

Eddyville stands as a clear example of how value-added agriculture can benefit our state.

The Department of Economic Development and the Department of Agriculture have been working on a joint project, which provides technical and financial assistance to renewable fuels and other value-added projects. It involves a two-pronged approach:

1. **Innovative Agricultural Products and Processes, a program to encourage development of new products.**

In this area, the most important step we have taken is to acknowledge that the future of our industry and our state lies in the development of value-added agriculture. More jobs and more income will result from processing our corn, soybeans and livestock.

One of our greatest successes to-date has been a product called ethanol. It has demonstrated the versatility of ag-related products by moving our farmers from not only feeding the world but fueling our cars as well.

Ethanol provides the world with a renewable energy source which is environmentally friendly. It has the potential to cause dramatic increases in the demand for corn. Currently, Iowa produces a third of the nation's ethanol.

Another success has been soy ink. Last year, the number of bushels of soybeans consumed by national soy ink production was roughly equivalent to what the state of Iowa produced.

There are other products such as Cerbitol™ produced by Roquette in Keokuk.

2. **Renewable Fuels Component, a program to support renewable fuel production facilities.**

Ethanol production benefits the livestock industry as well. By-products such as corn gluten feed, corn gluten meal and distillers dried grains provide a new, efficient feed for livestock.

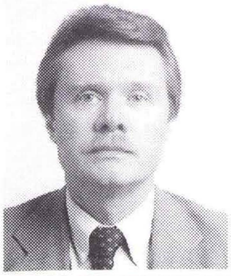
The livestock industry is important to Iowa. It is facing major challenges today, but I believe they are challenges we can face successfully.

When I formed the Livestock Revitalization Task Force, our goal was to increase livestock production in Iowa while addressing environmental and other concerns, which threaten its growth. The Task Force's recommendations are before the Legislature this year.

I am excited about the new opportunities that adding value gives Iowa agriculture. The future is promising.

We've seen what the success of just one product can do. Ethanol has an impact on everyone from the farmer to the factory worker to the livestock producer.

The state of Iowa must continue its commitment to value-added agriculture and take advantage of the opportunities that lie ahead.



Rural Development via Value-Added, Integrated Agriculture

Philip W. Madson,
President, Raphael Katzen Associates International, Inc.
Cincinnati, Ohio

Historically, agricultural communities were self-sufficient food, feed, and fuel systems. That is, when farming and local transportation were performed with draft animals, the fuel required to operate the farm and the community was grown by the farmer in the form of feed for the animals. Primary fertilization came from animal waste being reapplied to the soil. Most foods were produced locally.

With the advent of mechanization and industrialization, the food/feed/fuel relationship changed. Even fertilizer is "imported," and its fuel source is separate from the agricultural enterprise. This transformation resulted in farms being operated to maximize crop efficiency with minimum variety. As such, farming became highly dependent upon external factors. Fuel and fertilizer are purchased from manufacturers that are not part of the local farming community. Feed is sold from the farming operations to separate (and frequently distant) livestock feeding operations. Because of this specialization and narrowing of focus, farming throughout the industrialized world has become interdependent in infrastructure, transportation, fuel production, chemical production, etc., at the expense of the self-sufficiency of rural communities.

In the late 1970s, a movement developed in the United States to reintegrate the agricultural food/feed/fuel relationship. One component of the reintegration is the motor fuel ethanol industry, which was initiated to reestablish agriculture's contribution to the fuel requirements of the nation, and to add value, via integration, to basic agricultural production. This national program has taken two distinct paths.

One path is the large-scale agribusiness approach to the food/feed/fuel balance, as exemplified by corporations such as Archer Daniels Midland. As major processors of farm commodities, it's logical for the company to increase the number of useful, value-added products derived from basic commodity processing operations. Thus, the corn wet-milling industry became a major participant in the fuel ethanol business. Such projects as Ashland Oil's South Point Ethanol were predicated on the petroleum industry entering the agricultural raw material processing business. Ashland Oil is in the petroleum acquisition, refining, distribution, and retail business and entered the fuel ethanol business as a means of expanding and diversifying their raw material supply for their existing fuel businesses. While these types of operations, built around existing agricultural commodity and petroleum fuel enterprises, have contributed to the reintegration of agriculture into the energy field, their contribution to the overall development of rural farming communities has been minor.

The second path, which leads to significant rural development, is based in the farming community in which employment and value-added benefits remain in the locale. Two notable examples are the Reeve Agri-Energy operation of Garden City, Kansas, and the Pound-Maker Ethanol, Ltd. operation of Lanigan, Saskatchewan. Both enterprises developed around the concept that the grain produced in the farming community has two rational uses: livestock feed and fuel. These operations ferment locally-produced grain to fuel ethanol and a concentrated protein/fiber/fat cattle feed which is fed wet directly to cattle in the adjacent feedlot. In these projects, substantial fertilizer value is derived from the animal waste as well.

In these locally-integrated projects, the rural community benefits directly from high-quality employment, cash flow, and economic development, because the raw agricultural commodities are being processed locally into value-added feed, food, and fuel.

It is this type of vertically integrated agricultural enterprise that is appropriate for rural development in many communities throughout North America.

Benefits of integrated agricultural enterprise

In the traditional mode of operation, starch-based grains are grown, harvested, and delivered to an agri-business enterprise, which processes the commodities by separating the grains and oil seeds into their base components of oil (fat), starch, fiber, and protein. These components are blended into appropriate rations and sold back to the agricultural community for feeding dairy and feeder cattle, hogs, chickens, etc. Basic feed grains alone do not yield high quality rations because they contain excess starch in relation to fat and protein. Therefore, a portion of the starch must be disposed of by other means. In the U.S., large ethanol plants are located at agri-processing centers that transform this excess starch into fuel.

The principle of community-based integrated agricultural enterprise is to remove the excess starch and convert it to fuel at the point where the grain is grown and the cattle are fed. Two major products come out of an ethanol plant so structured: ethanol fuel, and a concentrated (protein/fat/fiber) feed material that is more appropriately balanced for dairy and cattle feeding operations. Therefore, the need to "import" protein/fat feedstuffs from outside of the community is reduced.

If a fuel ethanol plant processing whole grain was constructed as a stand-alone operation selling a dried cattle feed from the ethanol processing operation (in the manner of conventional agri-processing), the plant would require approximately 30 to 40% additional investment per bushel of grain processed, and operating costs would be 30 to 40% higher. This stand-alone plant requires not only a co-product drying operation, but also the utilities and infrastructure systems that are not required in an integrated operation. The only benefit derived from this additional investment is that the co-product feed concentrate (which is approximately one-third by weight of the original grain entering the plant) is produced in a dry form that can be shipped over long distances and stored, just as any major feed commodity. By integrating the ethanol plant with the grain production and animal feeding and/or dairy production, investment, transportation, and storage issues are minimized.

Simply put, the farmer grows the grain and processes it to a concentrated livestock feed and fuel ethanol. The ethanol is sold through fuel distribution channels. The high-protein, high-fat co-product feed leaves the ethanol plant in the form of a wet cake and syrup material (containing approximately 70% moisture). The cake and syrup can be moved and fed by conventional means, such as trucks and feed wagons, and can be managed by conventional feed-handling procedures.

While it is most advantageous for the ethanol plant and the cattle feeding or dairy operation to be adjacent, it also is practical to ship the wet feed over limited distances to the cattle. Depending upon cost, availability of transportation, and weather patterns, a radius of delivery for the feed may reasonably be as great as 30 miles. In some instances, feed could be delivered within even a 50-mile radius.

This manner of integration places the entire operation—from growing grain to producing fuel and processing the grain into a high-protein, high-energy animal feed, with subsequent feeding of livestock—all within one agricultural community. These enterprises produce high-quality employment for the local community. This type of integration further provides the opportunity to bring a number of farmers to join together in a cooperative fashion for joint ownership of a value-added, community-based feed/food/fuel enterprise.

Reeve Agri-Energy

Since the early 1980s, Raphael Katzen Associates International, Inc. (RKAII) and Reeve Agri-Energy have been developing high-level integration between ethanol production and cattle feeding of co-products, commonly called "wet cake" (wet distillers grains, or WDG) and "syrup" (condensed distillers solubles, or CDS). The original Reeve Agri-Energy integrated system demonstrated high efficiency and superior economics in both the ethanol plant and the cattle feeding operation by mixing hot WDG into the bunk ration and feeding hot, thin stillage via the cattle watering system. Under these conditions, the cattle feeding operation was water limited, and ethanol production capacity was determined by the water uptake of the cattle.

In 1991, Reeve Agri-Energy and RKAII developed plans to expand the cattle feeding operation, at the same time expanding the ethanol plant to a higher ratio of ethanol production to cattle-on-feed. This expansion required evaporation of the thin stillage to CDS. Thus, the integration balance was converted from a water-limited feeding system to a dry-matter-limited system.

In the present Reeve Agri-Energy integrated system, both the WDG and the CDS are blended into a feed mix destined for the feed bunk. Water is provided separately to satisfy the water uptake requirement of the cattle because the wet feed no longer provides all water requirements. This new integration allows for the production of 10 million gallons per year of ethanol from 3.7 million bushels of grain (2.7 gallons of undenatured ethanol per bushel of grain) with a cattle-on-feed population of more than 20,000 head. At this ratio of co-products to cattle, Reeve has reached new levels of efficiency in feeding distillers products, with excellent performance.

The success of the new integrated operation has been made possible through careful research and scientific management of the feeding protocol. The process results have been made possible because of the highly efficient ethanol process technology employed to maintain controlled consistency of the quality, composition, and production rate of the WDG and CDS.

When the project began in 1992, the ethanol plant was expected to be a 6 million gallons-per-year (2.3 million bushels of grain) facility, with further expansion potential as the cattle feeding operation dictated. The expanded plant, with new technologies, started up in December 1993. These new technologies minimized the quantity and maximized the quality of the WDG and CDS cattle feed. The processing technology results, along with excellent feeding results, allowed for immediate further expansion of the ethanol plant to its present 10 million gallons-per-year rate. This expansion was completed in fall of 1994, after it was determined that the efficiency of the ethanol plant could be maintained and that the high percentage CDS and WDG ration was economically beneficial for the cattle feeding operation.

In the final analysis, the Reeve Agri-Energy ethanol plant is a feed processing operation that produces a by-product: fuel ethanol. The plant is operated to a WDG and CDS standard demanded by the cattle feeding operation.

The technologies employed to bring the plant to this new level of effective capital and operating cost and fermentables conversion efficiency include RKAII's "no enzyme" cooking system, proprietary vacuum liquefaction, SSF (Simultaneous Saccharification and Fermentation), and integrated distillation and dehydration employing a direct-coupled, vapor-phase molecular sieve. The low-level energy recovery system includes an integrated, multi-effect evaporator for the production of CDS. Further energy integration includes low-level heat recovery to produce warm water for the fish-growing operation. Screens and presses are used for the separation of whole stillage and water removal from the wet cake.

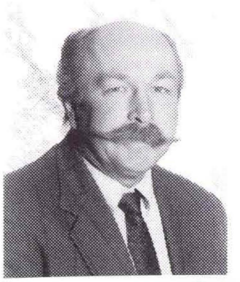
The performance results of the new technology have set a new standard for ethanol plants, with yields (corn and milo feedstocks) exceeding 2.7 gallons (undenatured ethanol) per bushel of grain, at a net energy consumption of fewer than 24,000 BTUs per gallon. Because of the high conversion rate of carbohydrate to ethanol, the yield of co-products is approximately 15 pounds per bushel of grain (dry matter basis). The combined WDG and CDS contain more than 34% protein (dry matter basis). The technology also has resulted in a more simplified plant design that is "user-friendly." Total cumulative investment since beginning the ethanol project in the early 1980s has been kept substantially below $1 per annual gallon of ethanol production, even though the plant has undergone three major expansions.

The elimination of the dryhouse in the Reeve integrated system of ethanol production and cattle feeding, along with the elimination of waste treatment and the systems, utilities, and costs associated with support of a dryhouse, have resulted in an efficient means of maximizing profitability of the co-products. The Reeve integrated system enhances the competitiveness of the cattle feeding operation by taking advantage of hot, wet co-products of high quality without the cost of drying, storage, and transport of distillers dried grains.

The Reeve Agri-Energy model of integrating ethanol production with direct cattle feeding results in rural economic development of the highest quality.

Conclusion

Experience over the last decade with the Reeve Agri-Energy operation has proven the validity of integrated agriculture and has demonstrated its economic advantage to the local community. Over the past four years, the Pound-Maker operation in Lanigan, Saskatchewan, which was modeled after Reeve Agri-Energy, also has demonstrated the value of this type of operation to the grain-growing and cattle-feeding community. The demonstrations are unambiguous. The agricultural community will benefit by adopting these strategies.



Organizing an Ethanol Plant Project

Larry Johnson
Consultant, Minnesota Ethanol Commission
Cologne, Minnesota

History of plant building

Due to the fear of a shortage of world oil supplies, the federal government created a program of loan guarantees to investors willing to build ethanol production facilities. This created nationwide competition to be the first on line with proposals to take advantage of limited guarantees. Unfortunately, in the rush to be at the front of the line, legitimate business planning became secondary to the ability to write a satisfactory application for a loan guarantee.

Reasons for previous plant failures

Hundreds of ethanol plant projects were in various stages of planning and operation throughout the Midwest during the late 1970's and early 1980's. Nearly every one of these ventures failed for reasons that have been documented in many publications. Since that time, most of the factors that contributed to the early failures have been corrected through experience and technology, or those factors no longer exist.

Unknown and untried technology. Process technology has improved many-fold when measured by the energy requirements of today's industry as compared to many of the early ventures. Improved yeasts and enzymes, shorter process times, lower capitalization costs, economy of size, improved plant configuration, and computerization have lowered the cost of production as well as energy requirements. These advances are readily available to every plant and should lower the risks of plant failure.

Inadequate capitalization. Underestimating eventual costs and lack of access to adequate capital plagued the majority of the early projects. Many cases are documented of farmers and investors losing many or all of their assets in the belief that successful plant operation was just around the corner. In contrast, some federal loan guarantees resulted in greatly inflated construction costs because of reluctance to take personal financial risks and, subsequently, inflated overhead costs that made debt service impossible. Financing remains the most difficult hurdle to overcome for plant builders, but tremendous progress has been made. The financial community, though still cautious, now has greater confidence in the plants because of proven technology, marketplace acceptance, government support, the environmental movement, precarious oil supplies, and more realistic business plans.

Poor product marketing. Ethanol initially was "dumped" on the market with very little research or promotion, billed as the answer to inadequate octane supplies resulting from the tetra-ethyl lead phase-out. The resulting real and perceived performance problems soon led to a very negative image of ethanol, and it could be marketed only at a discount. The change in marketplace acceptance for ethanol blends in the last decade is an amazing success story that has removed a huge element of risk from startup projects. Today ethanol is sold by truck, rail, and barge to all states, in most cases stored and offered by major terminals and refineries as a product option.

High capitalization costs. Many early plants struggled with very high overhead costs resulting from plant costs of $3 to $4 per gallon of annual production and double-digit interest rates. When we consider that plant costs have broken through the $2 per gallon level today, we must think that many of the early ventures were driven more by emotion and blind faith than any accepted form of business judgment. History will show, however, that many emerging industries were led by bold, visionary advocates who were a generation before their time and never witnessed the successes of their early efforts.

Poor management and expertise. Managers of early ethanol projects had very little relevant production experience upon which to draw except that of the beverage industry, which was not handicapped by the need to compete in price with gasoline. Due to inadequate financing, many managers of small projects were unable to hire expertise, and thus had to oversee construction, processing, financing, marketing, and management. Today, both experience and technical support are available, but many managers still are reluctant to hire such help. Often they pay for this reluctance with delayed startup dates and expensive mistakes.

Erratic markets. The late 1970s and early 1980s were a time of inflation and extremely volatile markets for both oil and farm commodities. The Payment-in-Kind corn set-aside program of 1983 resulted in corn priced at $4 per bushel. Oil prices decreased from nearly $40 per barrel in 1979 to less than $10 in 1986, while interest rates peaked at nearly 20%. While one cannot predict that similar times will not return, some of the same factors that created interest in the ethanol industry also created wild gyrations in commodity prices that caused many businesses to fail, even those which weren't beset by the same perils as the fledgling ethanol industry.

Present state of industry

The industry today consists of 39 to 43 producers, depending upon which list one uses. Most of these plants are survivors from the 1980s that gradually expanded, upgraded their facilities, and brought industry capacity to one billion gallons by 1992. The industry now is in its second phase of expansion, witnessing the first wave of new plant construction in nearly 10 years.

The current expansion is driven by expectations of expanded markets resulting from the Clean Air Act Amendments of 1990 and the extension of the excise tax exemption. Current industry capacity is projected to exceed 1.4 billion gallons; many expect capacity to expand to 2 billion gallons before the year 2000.

Size of various projects

Controversy has existed regarding the number of gallons a plant must produce to be efficient ever since the ethanol industry began the "modern" era of fuel ethanol production in the late 1970's. The only size that has been generally discounted as inefficient is the small, on-farm facility designed to produce ethanol for the farm's own use. Plants that measure production in "hundreds of thousands" of annual gallons simply cannot keep cost per gallon down. Plants also are rated on production capacity while operating 24 hours a day, and most farms don't have the labor available to provide round-the-clock operation.

It is basic economics that the more gallons across which fixed and operating expenses are spread, the lower the per-unit cost of production. Yet, technology and computerization have greatly reduced labor requirements for plants as small as five million gallons, making them much more competitive with many of the giants of the industry. One efficiency inherent in large plants is the confidence product purchasers have, both in quality and in the ability to deliver large volumes on time, to any location. To achieve this efficiency, many of the new cooperatives are considering forming marketing cooperatives similar to those of the Crystal Sugar, MNDak, and Southern Minnesota sugar cooperatives in marketing beet sugar.

Wet vs. dry milling

The discussion of wet vs. dry milling plants usually emerges at some point in each project's planning phase, and many raise the issue with no understanding of the differences between the processes. To put it most simply, a wet mill soaks the corn, enabling separation of some of the kernel's components; the separated starch then is converted to sugar (saccharification), fermented, and distilled into 200-proof ethanol. The pure stream of starch also can be sold as food or industrial grade starch, processed into syrup, sweeteners, or a variety of high-value products. A dry mill grinds the corn into a meal, adds water, saccharifies, ferments, and distills the entire mash, creating two products: ethanol and dried distillers grains with solubles (DDGs).

Wet mills cost more than twice as much per bushel of grind to build as dry mills, but the resulting variety of products can be considerably more valuable. Modern technology has greatly increased the efficiency of small dry mills to the point where they are very competitive with large wet mills. A dry mill eliminates the expensive process of creating the pure starch stream; the relative prices of gluten, corn oil, and DDGs determine which is the less expensive process of producing ethanol.

The cooperative structure

Many of the new projects, primarily those in Minnesota, are farmer-owned cooperatives. These require a greater share of equity to attract the necessary long-term financing. Privately owned ethanol plants with a profitable business history are able to tap commercial lenders or venture capitalists for 60% to 65% of project costs, while the cooperatives, with limited experience in this type of venture, usually must have at least 50% of equity capital in hand. Many of the new efforts are using the "MCP model," patterned after the very successful Minnesota Corn Processors wet mill plant in Marshall, Minn., which began production in 1983.

Cooperatives usually start with a group of farmers pooling a limited amount of funds or utilizing a local business entity such as a Rural Electric Cooperative, economic development association, or a grain elevator to provide initial office support services with which to begin an organization. The organizational effort usually consists of developing a preliminary business plan and scheduling a series of 10 to 25 producer informational meetings to explain the concept. Additional funds are collected at these meetings from any producer who wants to donate either five or ten cents in "seed money." The seed money is used to pay for legal, engineering, financial, and site work needed for the final business plan and prospectus required for the cooperative stock sale. In most cases, the seed money is deducted from the final price of the stock purchase.

In the case of a typical 15-million-gallon dry mill ethanol plant, six million shares of stock are available because the plant will grind approximately six million bushels of corn. Stock is sold in a minimum of 5,000 share lots at $2.50 per share; purchasers then are required to deliver one bushel of corn annually for each share of stock owned. Six million shares sold at $2.50 will provide $15 million in equity, thus providing approximately 55% of the total cost of the plant. The time required from the first informational meeting to actual groundbreaking varies from 10 months to two years, depending upon the abilities and aggressiveness of the board and any problems they encounter along the way. The single most trying part of the entire project is raising the necessary producer seed money and equity.

Certain factors are common to every successful project. The reputation, integrity, and ability of the organizers and directors are essential. Rumors and coffee shop talk go hand-in-hand with ethanol projects, and the public perception of the project may be positive or negative, often simply reflecting the attitudes of its promoters.

Media attention is essential for the success of any cooperative project. Anyone can stage a press conference to announce a project, but garnering continued positive coverage requires consistent communication, accurate information, fair treatment, openness, and possibly even the purchase of advertising.

Another useful tool is a method of informing bankers in various communities about the project and soliciting their input. An unfortunate fact of life is that most farmers must borrow a large share of the investment for the purchase of stock. They don't want to be apprehensive when they approach their banker for another loan in addition to their operating line. When bankers understand the project, they often encourage their customers to invest and can provide a tremendous positive impact on the project. They should be invited to a special informational meeting in advance of the farmer meetings, at which they can be presented with financial details before the loan requests are made.

A schedule of activities must be developed at the beginning of the project so that every potential investor can determine when equity will be needed, as well as to assess whether the project remains on schedule. Delays are inevitable, and it is important to face those delays and explain why they happened. There is no shame in making mistakes, but when mistakes are made and then covered up, the entire project loses credibility. Ethanol plant projects seem to be very sensitive to momentum, and nothing causes a project to lose momentum more quickly than investors losing trust in the decision-makers.

Organizational difficulties

An amazing number of hazards and obstacles await the board of directors as they begin the process of organizing and developing a farmer-owned cooperative ethanol plant. Many of them result from the very nature of farmers, who tend to be independent and comfortable relying on their own instincts than on the advice of those they hire. They also tend to underestimate the detail and complexity of an ethanol plant project. The following are some common difficulties faced and errors made by those boards.

We'll do everything right. Every project begins with unbridled optimism of those involved. Board members often feel that everyone is on the bandwagon, because they are only talking to supporters. Soon they begin to think that everyone within 50 miles is equally excited by the project. Only after informational meetings are poorly attended does the realization hit that other people may have lives which do not revolve around ethanol! It is very difficult to overcome the skepticism of enough farmers to raise the 50% equity necessary to achieve long-term financing.

Optimism is essential, but blind faith must not take the place of hard work and planning. Problems then become more difficult because they were not anticipated and can be dealt with only through reaction. As the unexpected problems lead to delays in the project, suspicions and jealousies cause many of the investors to lose faith, and the rumor mill begins. A realistic schedule and strategy that anticipate unexpected delays must be developed at the beginning of the project.

Losing focus. Second only to lack of any plan, losing focus on the plan is the most common cause of problems and delays. Many of the activities necessary to complete a project must be done simultaneously. It is very easy to overlook some complex organizational details and jump ahead to some of more visible activities such as the selection of engineering firms and plant sites.

Decision-making. Countless decisions must be made, not all of which need full board discussion. The board must create committees to be responsible for various phases of the project and then trust them to discuss and evaluate all relevant options. When the full board debates every detail, meetings become endless, and important decisions often are delayed or made in haste by a tired and frustrated board.

Emotion verses logic. Ethanol projects seem to elicit more emotion in many people than other business ventures. This can polarize differences of opinion and personalities on the initial board or steering committee and lead to some very "spirited" exchanges. Heated debates can be a healthy exercise if differences are left at the meeting and do not affect long-term relationships. Organizers may be reluctant to involve people from communities somewhat removed from the "preferred" plant site for fear of losing control.

Selecting a plant site. Plant siting also can be a divisive issue, as every community vies for the jobs and economic activity such a facility may produce. In reality, most cooperatively owned ethanol plants pay freight for corn delivery, thereby eliminating any differences in profitability resulting from proximity to the plant. The basic necessities for a plant site include rail access, an adequate year-round road, water supply, wastewater treatment facilities, and reasonably priced access to boiler fuel and electricity. Other factors to be considered are availability of labor, housing, local financial incentives, and even amenities such as restaurant, motel, hardware, and office supplies.

Choosing your advisors

Ever since the heady times of the 1970s when fears of permanent oil shortages led ethanol advocates to believe they were saviors of our national security as well as the answer to low commodity prices, there have been those who have taken advantage of idealistic entrepreneurs. They have sold unproved technology, promised non-existent financing, used all the money collected to sign up membership, and collected high fees for feasibility studies and myriad other services. Often the plant never got built, and the local money ran out along with the "expert," who moved on to make the same promises to another community.

In most cases, failure could have been avoided if a small amount of emotion had been replaced with common sense and some basic investigation had been done. What are some of the obvious areas to investigate following a stranger to the promised land of a successful ethanol plant?

- *Demand a list of qualifications.* Require a resume and a list of previous successful projects that the consultant has worked on. Check more than one reference on every project listed. Make sure at least one reference is someone other than those listed. If the reference is a company or corporation; check its assets, length of existence, number of employees, and whether the listed office even exists.
- *Technical term-dropping.* During the first meeting between local organizers and a prospective consultant, the advantage is very much with the consultant. He no doubt has some industry knowledge and usually is very adept at selling himself. Often, those without legitimate credentials will compensate by using technical terminology in an effort to impress. Someone who truly wants to be of assistance to the project will recognize the technical inexperience of the board and attempt to speak at their level.
- *Are previous projects relevant to an ethanol plant?* Certainly similarities exist between ethanol projects and other factories and processing plants. If the previous projects are not related to ethanol, the consultant should readily demonstrate access to someone with relevant ethanol experience.
- *What role did the consultant play in previous projects?* Many ethanol projects operating today can credit many people and companies who contributed in some way to the project completion. It is interesting how many resumes take credit for major contributions to any successful plant. Because exaggeration is easy, it is wise to find out if the consultant's contribution actually corresponds to the one claimed on the resume.
- *Reputation.* The ethanol industry really is quite small when it comes to communication. A few phone calls often can verify the authenticity of someone's reputation. Many people currently involved in the business have been around since the early days of ethanol and willingly offer information about those who claim to have contributed to successful projects. They can help prevent embarrassing failures.
- *Leveraged financing.* If the consultant claims access to large amounts of money from mysterious sources, it would probably be prudent to say an immediate goodbye. Ethanol always has had, somewhat undeservedly, the reputation of being a high-risk business. This is one reason financiers require a relatively high level of equity before providing financing. Some consultants have promised financing with as little as 5% equity at low interest rates due to the tax advantages enjoyed by foreign investors. It is a fact of life that higher risk requires higher interest rates, and low equity plus high interest rates equals a project that probably can't service debt. Foreign money, Wall Street investors, preferred stock, offshore capital, and sheltered income schemes are all terms that should raise a red flag—especially when the contacts are not divulged or the exact financial plan is not detailed. Some dealmakers even have suggested that farmer-owners can retain majority control with an investment of as little as ten cents per bushel!
- *Payment for services.* Payment for services should never be made in advance except for a small retainer as a show of good faith. Any legitimate consultant will accept the majority of payment upon completion of services as they are performed. To judge the true intent and confidence of any consultant, a significant amount of the proposed fees could be rolled into a performance bonus to be paid only upon the successful completion of the services under contract.

Integrated facilities

Small ethanol plants have less product over which to spread fixed and operating costs, so they often look for unique advantages to level the playing field with larger plants. The advantage that most frequently comes to mind is integrating an ethanol plant with a cattle feedlot, such as the Reeve facility at Garden City, Kansas, or Poundmaker at Lannigan, Saskatchewan. Such a facility lowers the per-gallon cost of construction and operation by eliminating the need for drying the distillers grain by feeding it wet, directly to adjacent cattle feedlots. Additional cost savings result from smaller boiler requirements, lower process costs, and elimination of wastewater treatment.

Other factors that can contribute to more efficient operation are sharing steam, heated water, or electricity with an existing facility, and utilizing other feedstocks such as waste carbohydrate, candy, or sugar from another food processing plant. Wastewater and scraps from potato processing and lactose from cheese plants currently are used in some parts of the country to provide both process water and product feedstock for ethanol production. The ethanol plant can acquire low-cost feedstock while saving another processing plant the cost of waste disposal. What is considered effluent by some environmental standards can be a valuable mineral or nutrient when added to the distillers grains.

Markets

Both ethanol and DDGs are competing in very large, existing markets currently occupied by other products: gasoline and protein meals, respectively. The advantage of existing markets eliminates some need for promotional efforts but does pose the challenge of replacing existing products. It also means that products are moving into markets with existing price structures, which can provide a reasonable estimation of future prices.

Ethanol prices. Due to the 5.4¢ federal tax exemption, ethanol actually has a price floor of approximately 54¢ over the price of unleaded gasoline. That is, when ethanol becomes cheaper relative to gasoline, it becomes more economical to gasoline marketers than gasoline itself and will begin to replace gasoline gallons. Ethanol also has an octane rating of about 115, which is a value not universally paid by the marketplace due to the current octane production capabilities of oil refineries. Demand and price support also result from federal clean air requirements for oxygen in gasoline.

Return on investment

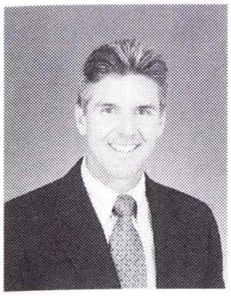
The processing of corn to ethanol can add from $1.50 to $2.50 in value to the market price of corn, depending on the current prices of corn, ethanol, and DDGs. An analysis of price history combined with plant costs and process efficiencies should provide a reasonable estimate of potential returns on investment for those providing equity to a project. A projected annual return on investment for the plant of 10% to 20% is not unreasonable. The percentage of borrowed funds and the interest rate of those funds then can be used to compute the return on equity. Such estimates only project the possibilities; they cannot account for poor management, unforeseen production difficulties, or changing government policies.

Agriculture is entering a new era—one that will be as significant as the invention of the tractor, hybridization of seeds, or the advent of chemical weed control. This era is one of value-added processing and marketing under the control of the producers of the commodity. Ethanol is on the vanguard of that movement because it has a ready-made market and a perfected technology. It represents the ability of the American farmer finally to move corn, which chronically has been in surplus, into a new market in which the farm does not compete with the production of his neighbors.

If a farmer markets an entire corn crop through an ethanol production facility of which the farmer is part-owner, there no longer need be a concern about corn futures because the farmer is no longer selling corn, but energy! The farmer is now producing a crop for the energy and oxygenate market in competition with imported oil. The competition is only imported oil because domestic production of oil is expected to decline by more than half in the 15 years from 1985 to 2000. The century of unlimited oil supplies in the U.S. is over, and once again the nation's farmers will step up to provide the raw materials to fill the need.

Fifteen-month schedule of activities for organizing an ethanol plant cooperative

Activities by month	List of necessary activities
0-1	Determine local interest
0-3	Identify core group of supporters
1-6	Seek out local economic development assistance
2-3	Check for state economic development assistance
2-3	Determine plant size and type
2-3	Estimate amount of capital needed
2-3	Do preliminary feasibility study
2-3	Select and appoint temporary board of directors
2-3	Meet with local government entities
2-3	Determine local permit needs
2-3	Schedule local farmer meetings
2-4	Form an expanded steering committee
2-15	Initiate media contacts
3-4	Hold information meeting for local bankers and elevator managers
3-4	Conduct farmer information and sign-up meetings
3-5	Request seed money (initial operating capital)
4-6	Complete final feasibility study
4-5	Open office
4-10	Investigate local financial assistance
5-7	Hire project coordinator
5-8	Interview process design companies
5-8	Visit existing plants
6-8	Develop business plan
6-9	Select process design company
6-9	Select general contractor
6-10	Sell stock
6-10	Collect first 50% equity
8-9	Contact permitting officials, begin permitting process
8-9	Contract with company to accomplish permitting
12-14	Complete financial package
14-15	Acquire permits
13-14	Collect remainder of equity from stock sales
15	Hold groundbreaking ceremony
16-17	Hire general manager
24-30	Start up plant, begin production



Future Ethanol Production

Bruce Heine
Director of Marketing and Sales, New Energy Company of Indiana
South Bend, Indiana

New Energy Company of Indiana is one of the nation's largest manufacturers of fuel grade ethanol. Dry mill production of ethanol, distillers dried grains (DDG) and carbon dioxide (CO_2) has been increasing each year since the company began operation in 1984. Currently, New Energy produces 85 million gallons of ethanol, 270,000 tons of DDG and 160,000 tons of CO_2 annually.

According to published reports, there is currently new plant construction and expansion of existing facilities that will result in an additional 235 million gallons of fuel ethanol annually. This will bring the industry capacity to more than 1.6 billion gallons in 1996. These projects for the most part are driven by the increasing demand for ethanol. Several of the new plants are dry milling operations that bring additional distillers grains and CO_2 supply along with ethanol. A significant variable in plant size has been the availability of the federal small producers' credit for plants of less than 30 million gallons of capacity. The incentive provides 10 cents per gallon for the first 15 million gallons produced.

Iowa currently has five operating plants owned by ADM, Cargill, Roquette America and Manildra. According to published reports, there are two additional projects under consideration. One of the benefits for two existing plants in Keokuk and Clinton is transportation advantages against land-locked plants to ship ethanol and co-products to the Gulf Coast. These transportation efficiencies will become more important as the ETBE industry develops and as the East Coast market for ethanol expands. In fact, EPA indicates in their Regulatory Impact Analysis for the Renewable Oxygenate Standard that transportation from Clinton, Iowa, to New York via water is very competitive for ethanol (see Table 1).

Transportation efficiencies are important to plant locations; corn cost and availability, state incentives, market growth, utility costs, a state's enthusiasm for increased ethanol production and other political variables also help consummate the location of plants. Iowa has several very appealing advantages to offer industry but must currently compete against attractive state incentive packages in Nebraska and Minnesota.

Iowa has offered ethanol blenders an excise tax exemption to help increase the state's market share of ethanol-blended gasoline. In fact, more than 35% of the state's gasoline is blended with ethanol, one of the highest in the nation. It has been our belief at New Energy that expanding the market through state incentives like Iowa's will lead to increased production. Iowa's retail pump labeling requirement is also fair for the ethanol marketer. The state statute requiring ethanol and MTBE to be labeled is consistent with national standards and helps prevent anti-ethanol advertising.

There is no doubt that the regulatory environment in Iowa promotes ethanol.

When evaluating the future for ethanol expansion, it is also relevant to overview the critical issues affecting industry today, including:

- current government incentives,
- regulatory/legislative action,
- clean air market demand,
- octane market demand, and
- the relationship to competing oxygenates.

There has always been a level of uncertainty in the ethanol industry that is indirectly a result of government incentives, which have been in place since 1978 to provide all companies an economic incentive to blend ethanol in their gasoline.

The excise tax exemption and blenders' tax credit were most recently targeted by select members of the 103rd Congress for a rapid phase-out, which would be devastating to the existing industry. These incentives are scheduled to expire in the year 2000. Along with the tax incentive issue has been uncertainty with the environmental issue of a summer-time vapor pressure waiver for ethanol-blended gasoline. Also, consider the uncertainty of several governors recently "opting out" of the EPA's Reformulated Gasoline Program (RFG), which decreased demand for all oxygenates. Moreover, the EPA's response to Governor Thompson's (Wisconsin) request to delay the RFG program in Milwaukee due to headaches and health effects associated with MTBE appropriately raises concern from ethanol producers.

Every problem presents an opportunity and there are also several positive ways to consider final EPA action. First, EPA did not ban oxygenates, which was widely speculated prior to the February 24, 1995, letter to Governor Thompson. Second, EPA called on the oil industry to provide clearly visible pump labels to the public on oxygenates including MTBE and ETBE. Third, EPA will sponsor workshops for mechanics in the Milwaukee area to overview the RFG program. It appears that a lack of education on the RFG program for mechanics and consumers is at the base of this entire program.

Table 1. Cost to Ship Ethanol to New York (per-ton basis)

Origin	Annual Tons	Rail Cost ($/Ton)	Water Cost ($/Ton)
Decatur, IL	82,349	54.37	34.70
Peoria, IL	50,722	65.11	26.60
Pekin, IL	25,361	65.46	29.83
South Bend, IN (via New Orleans)	19,020	50.48	44.98
South Bend, IN (via Great Lakes)	19,020	50.48	40.47
Cedar Rapids, IA	43,114	65.30	37.35
Clinton, IA	35,505	61.93	28.47
Blair, NE	20,288	73.59	42.24
Range		**50.48 - 73.59**	**26.60 - 44.98**
Weighted Average		**61.18**	**33.34**

Table 2. Cost to Ship Ethanol to New York (per-gallon basis)

Origin	Annual Tons	Rail Cost ($/Gallon)	Water Cost ($/Gallon)
Decatur, IL	82,349	0.180	0.115
Peoria, IL	50,722	0.215	0.088
Pekin, IL	25,361	0.216	0.099
South Bend, IN (via New Orleans)	19,020	0.167	0.149
South Bend, IN (via Great Lakes)	19,020	0.167	0.134
Cedar Rapids, IA	43,114	0.216	0.123
Clinton, IA	35,505	0.205	0.094
Blair, NE	20,288	0.243	0.140
Range		**0.167 - 0.243**	**0.088 - 0.149**
Weighted Average		**0.202**	**0.110**

Lastly, the U.S. Court of Appeals heard the oral arguments from the Justice Department and the American Petroleum Institute on the merits of EPA's Renewable Oxygenate Standard (ROS). The hearing did not appear to advance the merits of the ROS, according to witnesses. The outcome of this debate is important for the future of the industry as the ultimate regulation will provide continued pressure on refiners to optimize renewables. There is a tremendous amount of Congressional support for the ROS implementation. Among these leaders is Senator Richard G. Lugar of Indiana, who has been a longtime advocate for ethanol.

All of this uncertainty aside, it is New Energy's view that ethanol demand will continue to grow due to a few basic fundamental public policy benefits. Most notably, ethanol displaces imported oil. Iowa is dependent on imported sources of liquid fuel. It would seem likely that many Midwestern states would adopt state requirements for the use of renewables for energy security reasons in the future, irrespective of the federal initiatives. The policy of growing corn, processing the corn into ethanol and marketing the ethanol in the same state in which the corn is grown and processed is a good policy.

Currently, the highest and best use for fuel ethanol is as an oxygenated additive to hydrocarbon RFG and winter-time oxygenated fuel. Ethanol competes against the value of other oxygenates, most notably MTBE. The industry has developed a significant demand for ethanol's octane value over the years and EPA recently studied the impact of the Renewable Oxygenate Standard for RFG and decided to phase it in due to their desire to prevent large migration away from ethanol's traditional octane markets.

Market flexibility

As I build the case for continued growth in ethanol demand, along with increased dry mill production comes DDG and CO_2. I will focus first on DDG. Unlike ethanol, which can be exchanged between producers to lower freight costs, DDG is mostly producer specific.

Nutritionists, feed mills and farmers may desire certain color, protein and fat content that varies among plants. Nearly all of our DDG is used as a feed supplement in the dairy cattle industry with only a trace for poultry. It makes sense to concentrate on markets that are close to home or where you have a freight advantage.

Many plants will not have water access to barge DDG to the Gulf Coast for export and will potentially rail DDG to a transloading facility to barge. This is obviously going to add costs, which yield a lower netback to market. It becomes a matter of working the rail and truck market to let farmers know you're there and you want their business with the objective of expanding the domestic market.

Several large ethanol producers of CO_2 market their product directly to food manufacturers, beverage producers and others. Other plants have entered into agreements with companies to store, transport and market their product for them.

There are regulatory tax issues which have been raised by the CO_2 industry under current debate in Washington. As with all of the issues that affect ethanol plants in Washington, I strongly encourage any interested new producer to join the Renewable Fuels Association, which represents more than 95% of the domestic ethanol industry.

Closing

There is great satisfaction in being involved in the ethanol industry. I believe what we do is good and right—for all the best reasons. Moreover, it is patriotic and is consistent with our culture as Midwesterners and Americans.

The future looks good for all members of the ethanol industry if the backbone of the industry—the American farmer—remains strong.

Wet and Dry Milling Explained

The discussion of wet versus dry milling usually comes up whenever ethanol production is discussed. Many ask the question without any understanding of the differences between the processes, so here's a look at the basics.

Wet milling

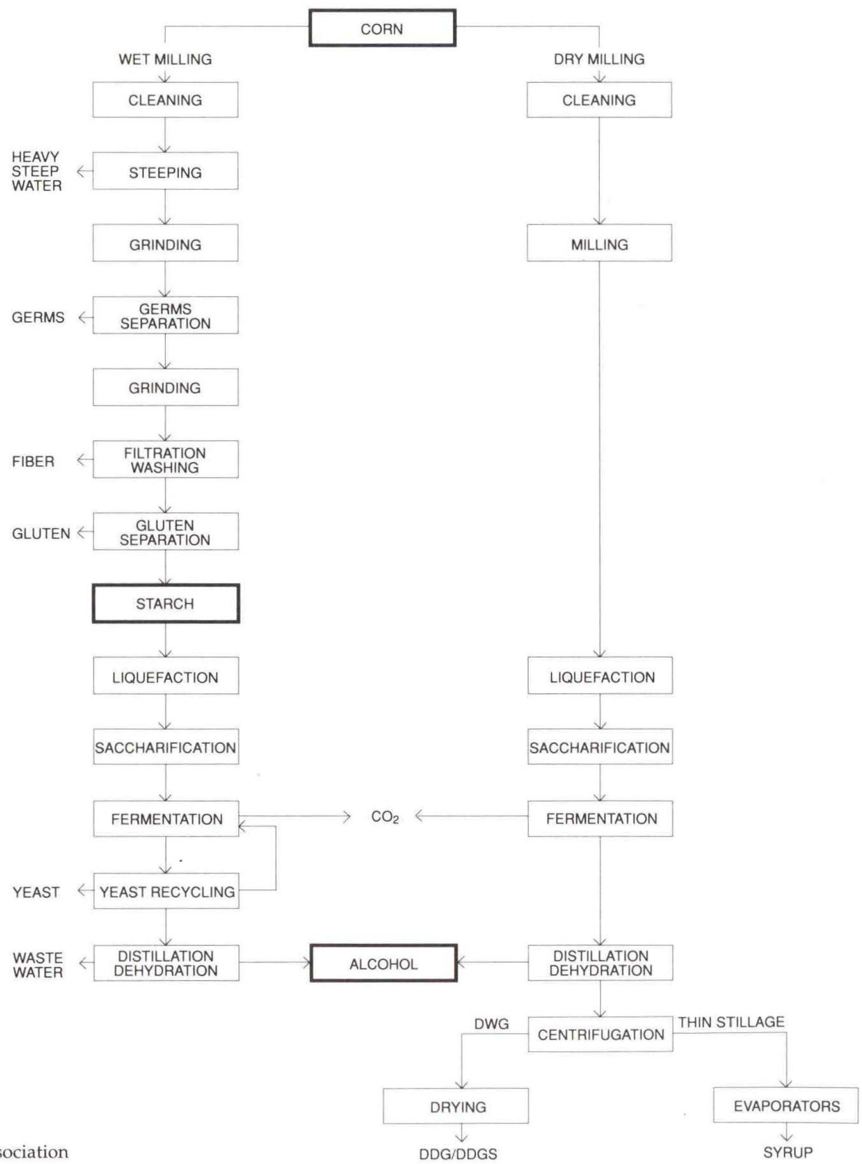
To put it most simply, a wet mill soaks the corn, enabling separation of some of the kernel's components and the separated starch is then converted to sugar (saccharification) and fermented and distilled into 200-proof ethanol.

The pure stream of starch can also be sold as food or industrial grade starch, processed into syrup, sweeteners, or a variety of high value products. Wet mills cost more than twice as much per bushel of grind to build as dry mills, but the resulting variety of products can be considerably more valuable.

Dry milling

A dry mill grinds the corn into a meal, adds water, saccharifies, ferments and distills the entire mash, creating two products—ethanol and dried distillers grains with solubles (DDGS). Modern technology today has greatly increased the efficiency of small dry mills to the point where they are very competitive with large wet mills for the production of ethanol. A dry mill eliminates the expensive processing of creating the pure starch steam before fermentation.

Relative profitability of the two processes depends on the relative prices of gluten feed, gluten meal, corn oil, starch and DDGs determine which is the least expensive process to produce ethanol.



Source: Minnesota Corn Growers Association

Ethanol Facts

Iowa Corn Growers Association

Ethanol and the Clean Air Act

- The federal Clean Air Act mandates the reduction of carbon monoxide levels in nearly 35 U.S. cities that have the highest levels of pollution. Motorists in those cities are required to use oxygenated fuel additives, such as ethanol, during the winter months.
- Beginning in 1995, the Clean Air Act requires year-round use of clean-burning fuels to reduce ozone formation in the nation's nine smoggiest metropolitan areas.
- Monitoring of 20 metropolitan areas participating in the Clean Air Program found that the number of days during which carbon monoxide pollution reached excessive levels was reduced by 95%.
- Reformulated gasoline, blended with ethanol to reduce ozone pollution, could create a new market for 150 million bushels of corn in 1995. This is equal to 12 bushels per acre for each acre of Iowa corn.
- Ethanol is the "cleanest" oxygenated fueled additive available. A 10% ethanol blend contains 3.5% oxygen which reduces hazardous carbon monoxide levels.
- Ethanol helps lower carbon monoxide emissions from most cars by more than 25% and reduces carbon dioxide emissions by 30%.
- General Motors and Chrysler encourage the use of ethanol in their autos as a method of reducing air pollution.
- 11% of U.S. gasoline sales—more than one gallon in every 10—are ethanol-blended fuels.
- Over a trillion miles, or 40,000 trips around the world, have been driven in the U.S. using ethanol-blended fuels since 1978.

Ethanol and agriculture

- In 1993, more than 480 million bushels of corn were used to produce ethanol in the U.S. Only 8 million bushels, less than 2% of the 1993 amount, were used in 1978 when the Iowa Corn Checkoff Program began.
- 411,000 bushels of Iowa corn are processed daily into ethanol—that's equal to the corn produced on 3,483 acres every single day!
- Ethanol production added an estimated $176 million to the value of the 1993 Iowa corn crop. That's approximately $16 per acre in additional income.
- More than 2.9 billion bushels of corn have been processed into ethanol over the past eight years.
- An acre of corn produces 300 gallons of ethanol.
- Ethanol production also creates an excellent livestock feed. Corn gluten is fed to hogs, cattle, and poultry with no negative effect on carcass weight or quality.

Ethanol and Iowa

- More than 40% of all gasoline sold in Iowa is a 10% ethanol blend.
- Ethanol-blended fuels can be purchased at nearly 2,000 service stations, convenience stores and farm co-ops in Iowa.
- More than 565 million gallons of ethanol-blended fuel were sold in Iowa in 1993. That's 60 million gallons more than just the year before!
- Since the Iowa Corn Checkoff Program went into effect 16 years ago, 850 million bushels of Iowa corn have been processed into ethanol.
- Ethanol production generates $1.5 billion in economic activity for Iowa.
- More than 12,000 jobs are affected by the production of ethanol in Iowa, including 2,550 in the corn processing industry associated with ethanol production.

Ethanol and energy

- Every 60 seconds, taxpayers spend more than $100,000 on imported oil. On the other hand, 70 to 80 cents of every dollar spent on ethanol in Iowa stays in Iowa.
- One gallon of ethanol yields a minimum of 33% *more* energy than is required for its production.
- The 1.2 billion gallons of ethanol produced in the U.S. in 1993 reduced foreign oil imports by more than 57 million barrels.
- 5,902 barrels of oil are imported every minute—the equivalent of 99,000 bushels of corn in the form of ethanol.

Ethanol and the future

- ETBE, a derivative of ethanol, is being tested as a motor fuel additive that increases octane and reduces air pollution. ETBE could provide another 200 million bushel market for U.S. corn growers.
- Fourteen city buses in Peoria, Ill., are powered by converted diesel engines that burn 100% ethanol. If only half the nation's mass transit diesel buses switched to ethanol fuels, it would create a new market for 100 million bushels of corn per year.
- The automobile industry is in various stages of design, testing, and production of cars which can operate on an ethanol content up to 85%. The state of Iowa has purchased 80 of these cars and all other state vehicles are required to use 10% ethanol blends.

Iowa Ethanol Production (Estimated Capacity)

Iowa Corn Growers Association

Company	Million Gallons	Million Bushels
Archer Daniels Midland Cedar Rapids and Clinton	375.0	150.0
Roquette America Keokuk	14.5	6.0
Manildra Energy (fuel grade & industrial) Hamburg	6.0	2.5
Cargill, Inc. Eddyville	28.5	11.5
Total	424.0	170.0

Source: Iowa Corn Checkoff Program, 1200 35th Street, Suite 306, West Des Moines, IA 50266.

U.S. Ethanol Production

Iowa Corn Growers Association

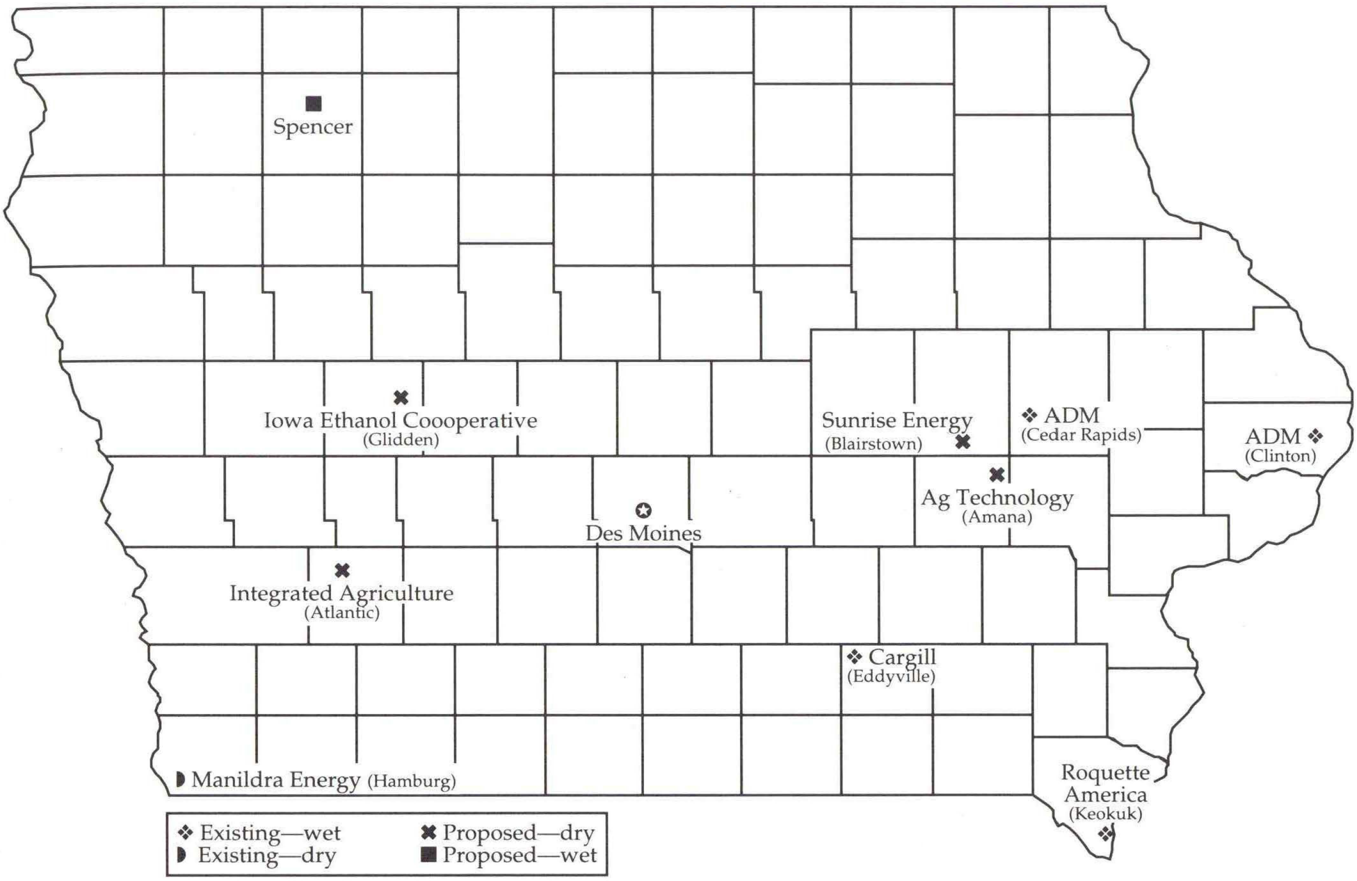
Year	Million Bushels	Million Gallons
1978	8.0	20.0
1979	8.0	20.0
1980	16.0	40.0
1981	30.0	75.0
1982	85.0	212.5
1983	150.0	375.0
1984	200.0	500.0
1985	240.0	600.0
1986	300.0	750.0
1987	340.0	850.0
1988	350.0	875.0
1989	360.0	900.0
1990	385.0	962.5
1991	400.0	1,000.0
1992	460.0	1,150.0
1993	480.0	1,200.0
1994	568.0	1,420.0
1995*	680.0	1,700.0
2000*	930.0	2,325.0

*Projected

Source: Iowa Corn Checkoff Program, 1200 35th Street, Suite 306, West Des Moines, IA 50266.

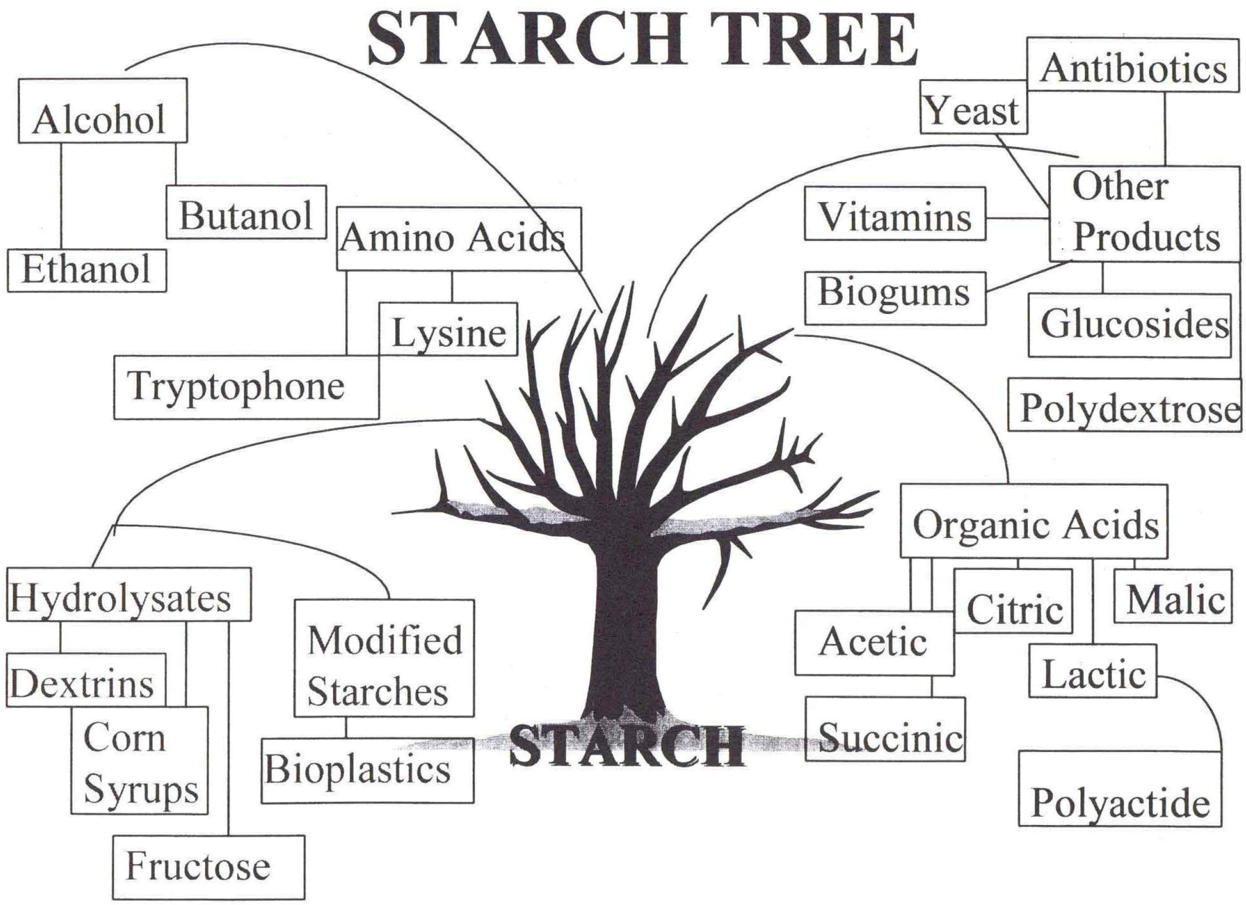
Iowa Ethanol Plants

Iowa Corn Growers Association



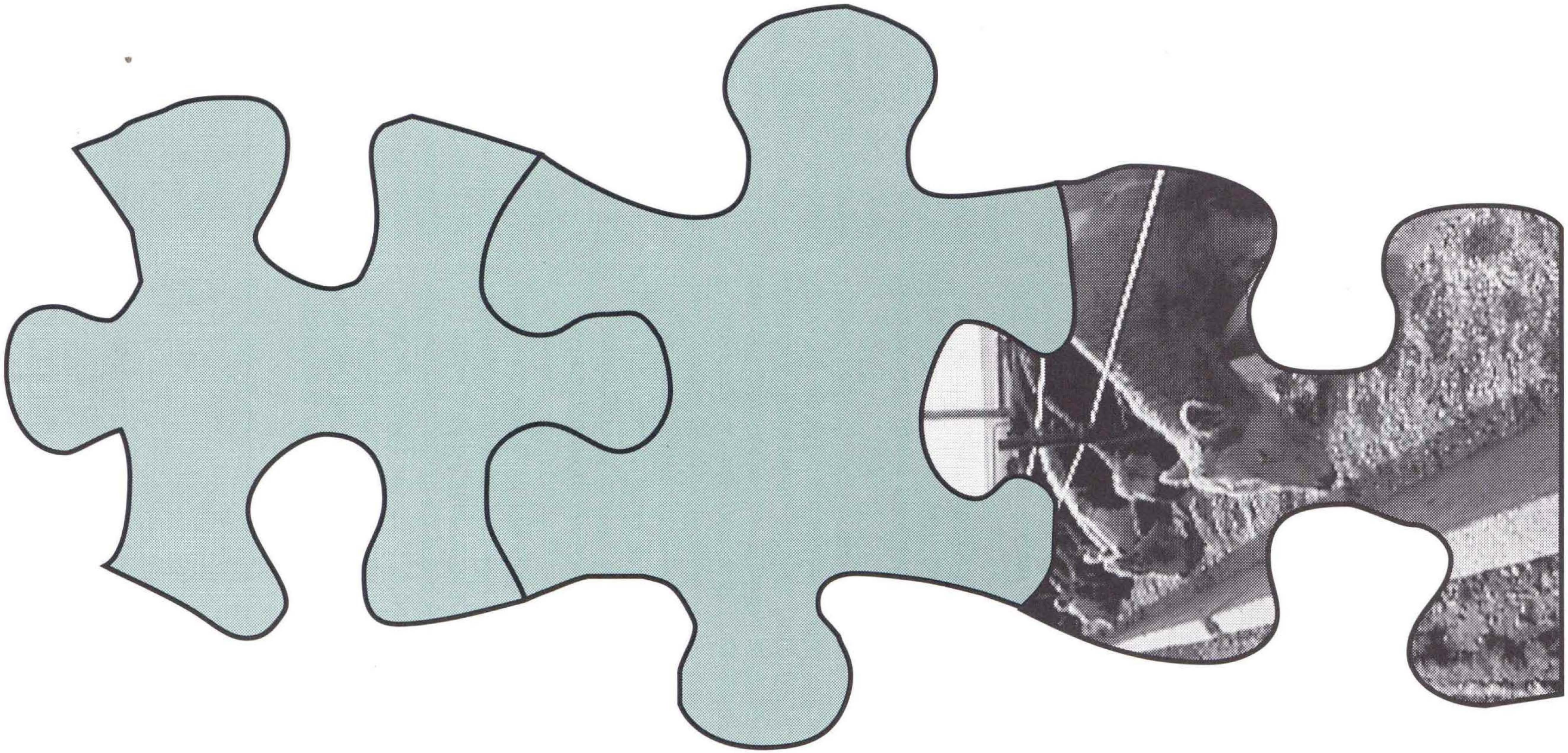
New Products from Corn

National Corn Growers Association



Note: This shows the variety of products made for corn starch. It was used at the conference in a presentation by Robert A. Mustell, Research and Commercialization Manager, National Corn Growers Association, St. Louis, Missouri.

The Cattle Industry



Feed Products from Corn

Jerry C. Weigel
Vice President, Nutrition/Tech Service, Archer Daniels Midland Co.
Decatur, Illinois

The use of industrially produced starch and fuel alcohol from 1990 through 1995 and beyond has been projected to increase by an average of 10% per year. Much of this increase results from the Clean Air Act Amendments of 1990. Today, we will discuss how this growth and the dynamics of animal feeding have worked together. We're going to talk about microbial fermentation of corn and the ways in which corn can be converted to value-added products. By "value-added," I mean taking a known commodity and processing it to add value, as well as having more credit revert to the commodity itself.

We can do this with corn—converting starch to dextrose to alcohol, sweeteners or various other primary products—as well as with the co-products from the processes. In industry and academia, the term is "by-product;" those of us who understand industrial processing use the term "co-product." Today, we will discuss the co-products that come from the wet and dry milling of corn.

There are two basic processes for producing ethanol from corn: "wet milling" and "dry milling." More than 70% of U.S. ethanol co-products are the result of the wet milling process.

In wet milling, the corn refiner wants starch to: 1) refine and improve the starch, 2) produce corn sweeteners, 3) make alcohol, 4) sell the oil, or 5) produce further fermentation products with dextrose as the energy substrate. In any case, the co-products are the same.

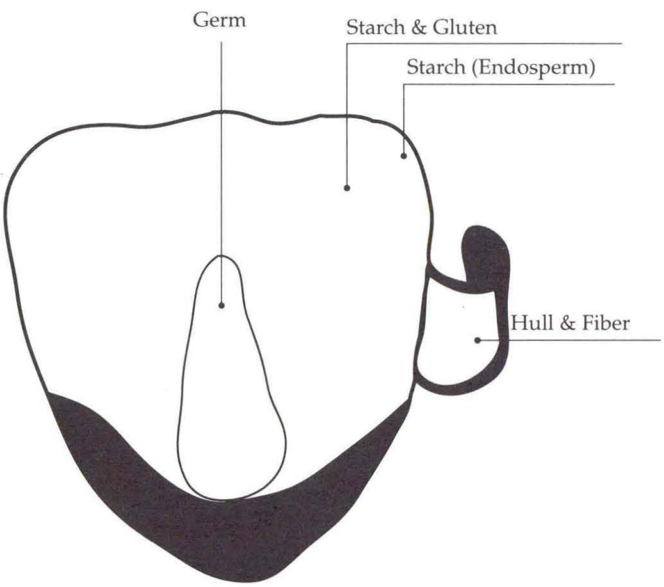


Figure 1. Components of corn.

In Figure 1, a kernel of corn is sliced lengthwise from top to bottom, disclosing the primary constituents:

1) Starch—the lighter area in the illustration. Starch is found at the top of the kernel, on the sides and in the middle of the kernel. This is the most abundant constituent, approximately 60%.
2) Gluten—the dark portion of the illustration. This is where most of the protein is found.
3) Hull or fiber or the outside of the kernel. It is part of gluten feed.
4) Water, which represents about 14% of the kernel.
5) Germ or the seedlike pod at the bottom of the kernel where the oil is found. Oil represents 4% of the kernel.

The processes are very different, as are the co-products. In the wet process, the grain is cleaned and water is added to it. This allows the kernel to swell or steep, then the components are separated and each is used as an ingredient for a separate part of the process. In the dry-milling process, the grain is cleaned and ground dry, and the starch is used in the conversion from yeast to alcohol.

The co-products from the wet-milling process (see Figure 2) are as follows:

1) Corn germ meal is the ground germ after starch removal, in some cases with oil and sometimes de-oiled. It usually contains 24-26% protein and makes an excellent cattle feed.
2) Condensed fermented corn extractives, steep liquor or steep water refer to the same co-product. It generally contains 40-50% solids. It is a high-protein ingredient (45% plus on a dry- matter basis, or DMB). It has been used in liquid feeds for years. Much of the steep liquor finds its way into corn gluten feed.
3) Corn gluten meal is the 60% protein, high-energy feed used in all phases of livestock feeding. Its most important role may be in poultry feeding as a source of methionine, pigmentation and energy. It also is a great source of rumen undegraded protein.
4) Corn gluten feed is the co-product with the greatest material balance at more than 12 lbs./bushel. It may be used in all phases of animal feeding. The application that has been researched the longest and with the most effort is feed for dairy and beef cattle. The research clearly has demonstrated that

Figure 2. Shows what occurs in the wet-milling process.

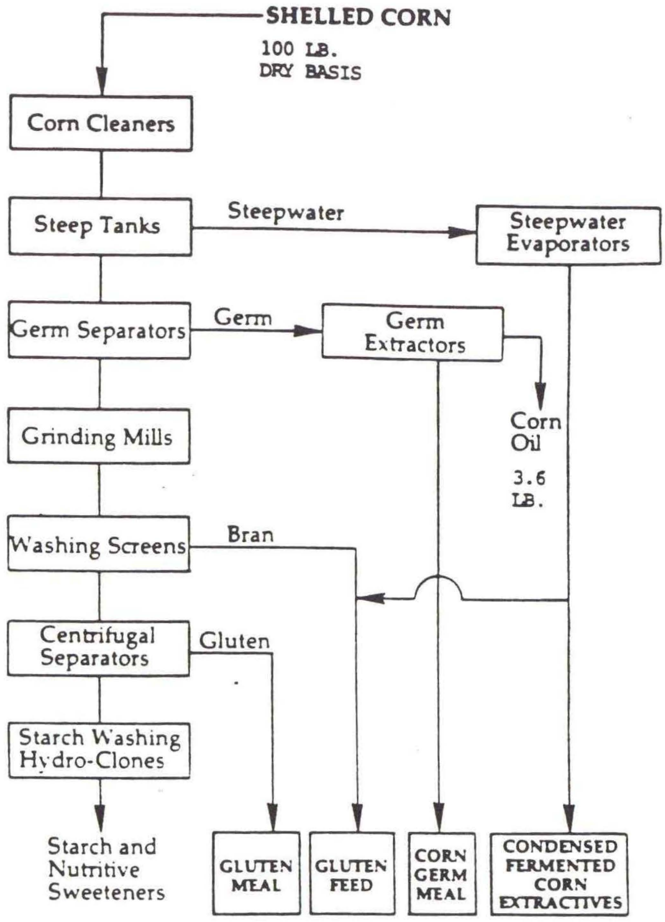
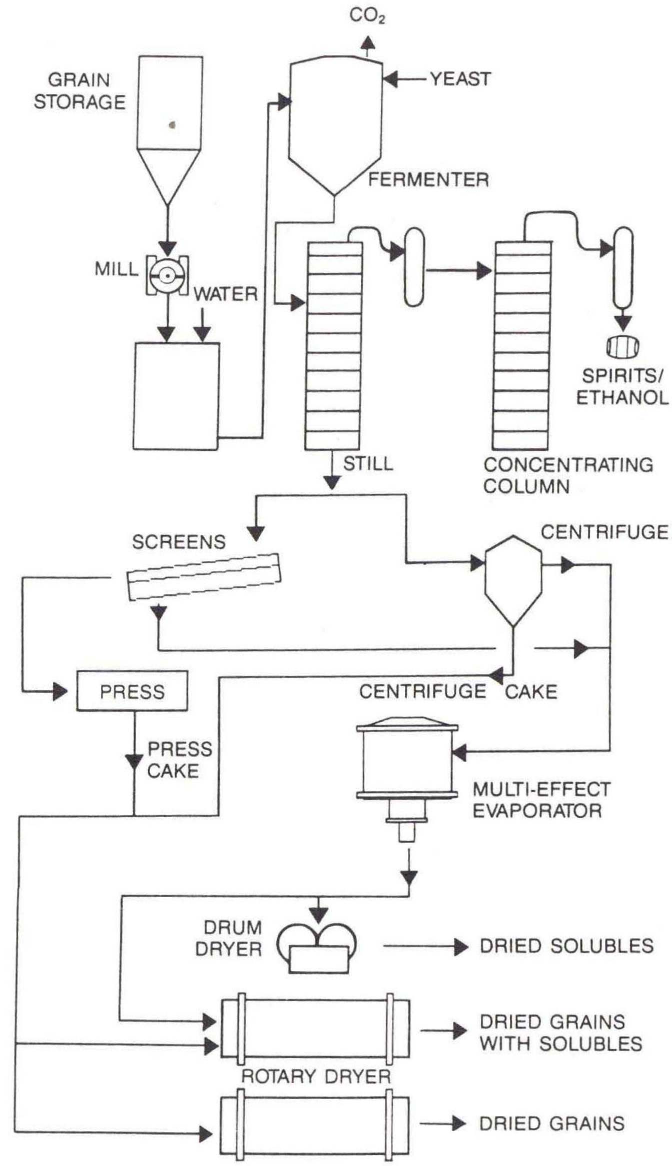


Figure 3. Shows what occurs in the dry-milling process.



corn gluten feed is an excellent energy source, effective fiber source, available source of essential minerals (except calcium) and a feedstock that encourages feed intake by the animal.

The co-products from the dry-milling process (see Figure 3) are as follows:

1) Distillers dried grains (DDGs) or the fiber that has been dried without the stillage applied. Historically, this has found its way into cattle feeds.
2) Distillers dried solubles (DDSs) or the water-soluble components of the process that have been dried.
3) Condensed distillers solubles are those which have been condensed by evaporation, ultra-filtration or membrane separation.
4) Distillers dried grains with solubles (DDG/S) are the ingredient most frequently used by the feed industry. Research over the past decades has demonstrated that DDG/S is consistently a great source of protein and energy for dairy cattle and grow/finishing cattle. Recent work has also suggested it has some application in aquaculture.

Corn gluten feed and DDG/S are used by the European Union because of a number of factors, especially certain tariffs on cereal grains and the price relationship with other middle- or high- protein feedstuffs. In addition, the livestock nutritionists who practice in Europe like to use gluten feed and distillers because the animals perform well on it. We continue to see large volumes of these ingredients go to Europe. We are also seeing gluten and distillers grains in rations in Mexico. Many of the large dairies have tried both of these ingredients with favorable feeding results. With the cost of certain pigmenting agents, corn gluten meal also is going into many poultry feeds. The Mexican nutritionists realize all the nutritional benefits of gluten meal as well.

Clearly, new uses are being found for these co-products. Recent trade talks and educational seminars in the Pacific Basin have generated much interest in gluten feed and meal. The past four years of drought in Australia have created interest in gluten feed for their confinement feeding industry, freeing wheat and barley for feeding poultry and swine. There has been interest in China, also.

These markets are only developing and will take time; we will continue to move these co-products to the E.U. Also, several of the new European plants are located in areas of livestock production and are promot-

Table 2. Nutrient composition of corn wet-milling feeds.

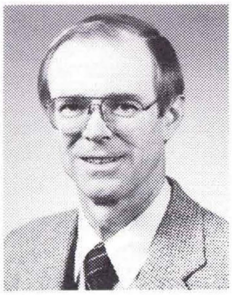
Nutrient	Corn gluten feed	Corn gluten meal	Corn germ meal	Corn steep liquor
Protein (%)	21.00	60.00	22.00	25.00
Fat (%)	3.60	3.00	1.00	—
Fiber (%)	8.40	3.00	12.00	0.00
ADF (%)	9.80	5.00	14.00	0.00
Arginine (%)	.78	2.08	1.30	1.00
Histidine (%)	.61	1.40	.69	.70
Isoleucine (%)	.88	2.54	.69	.70
Leucine (%)	2.20	10.23	1.79	2.00
Lysine (%)	.64	1.01	.90	.80
Methionine (%)	.37	1.78	.58	.50
Threonine (%)	.78	2.22	1.09	.90
Tryptophan (%)	.15	.30	.20	.05
Xanthophyll mg/lb	—	225.00	0.00	0.00
Linoleic acid (%)	—	3.20	—	0.00
Choline (%)	688.00	160.00	738.00	1550.00
Niacin mg/lb	32.00	27.00	13.00	38.00
Riboflavin mg/lb	.90	.90	1.80	2.70
Thiamine mg/lb	.90	.10	2.00	1.30
Biotin mg/lb	.15	.08	.01	.15
Potassium (%)	1.50	.20	.34	2.40
Phosphorus (%)	1.00	.48	.30	1.80
Magnesium (%)	.50	.08	.30	.71
Calcium (%)	.10	.07	.04	.14
Sulfur (%)	.30	.65	.30	.60
Iron mg/lb	165.00	128.00	153.00	50.00
Zinc mg/lb	114.00	14.00	42.00	32.00
Manganese mg/lb	26.40	3.00	1.80	13.00
Copper mg/lb	6.00	11.00	1.80	7.00
Metabolize energy-kcal/lb				
Chicks	830.00	1676.00	768.00	725.00
Hens	830.00	1676.00	—	725.00
Turkeys	960.00	—	—	—
Swine	1260.00	1600.00	1368.00	—
IDN (%)	89.00	80.00	67.00	40.00
Net energy (gain) mcal/lb*	.60	.60	.45	—
Net energy (maint.) mcal/lb*	.89	.89	.70	000.00
Net energy (lactation) mcal/lb*	.88	.85	.70	—

* 100% dry matter
—Unknown

corn starch converted to dextrose. We will continue to see 8-10% annual growth in lysine use and geometric growth in other amino acids such as threonine and tryptophan. As the market for these products expands, so will the demand for corn refining co-products.

We also will see corn co-products find their way into new animal applications. Aquaculture has tremendous growth potential as a co-product market, specifically corn gluten meal and distillers grains. Some tilapia in the U.S. are being fed diets containing no imported fish meal; instead, they are fed co-products from corn. Fish performance exceeds that of former fish meal programs. As we better understand the amino acid requirements of breeding animals, especially for the amino acids valine and isoleucine, we see tremendous opportunities for corn gluten in swine programs.

In closing, ethanol production is expanding and new uses for dextrose are increasing; consequently, more co-products will be available for our use in livestock production. New facilities are being built to meet this growing demand. Many of the new facilitie are in intense livestock-producing areas. If you are a feed formulator, manufacturer, feeder, researcher or consultant in the field of animal feeds or feeding, seek out these co-products and evaluate them based on all their nutritional properties, not just cost per ui of protein.



Utilization of Corn Processing Co-Products as Feed for Cattle

Allen Trenkle
Distinguished Professor, Animal Science, Iowa State University
Ames, Iowa

Introduction

Industrial use of corn increased dramatically during the 1980s and has continued to expand. In 1975, 500 million bushels of corn, or about 12% of national production, were processed. By 1993, that use had increased to more than 1.5 billion bushels, or about 23% of production. Research and demand for new products derived from corn have positioned the corn refining industry for continued growth. States such as Iowa should welcome this future and encourage further development of crop processing. Crop processing not only adds value to renewable raw materials, it also provides opportunities for restructuring agriculture to be more sustainable far into the future.

Exporting grain results in loss of valuable nutrients, namely nitrogen, phosphorus, and potassium, which then must be imported as fertilizer to sustain high-yielding grain production. Corn processing, on the other hand, results in export of products containing primarily carbon, oxygen, and hydrogen, which are fixed into the crop from the air by sunlight. If the by-products (co-products) of grain processing are kept within the state and effectively redistributed back to the farms, the critical nutrients are recycled, and fewer of these nutrients will have to be imported. Achievement of an effective redistribution system requires obtaining economic value from the co-products. At present, the co-products of corn processing have the most value as feed for livestock.

Co-products

A major portion of the corn processed in Iowa is wet-milled in larger plants to produce starch, oil, and corn gluten meal, with corn bran and steep water as co-products. The steep water is condensed and marketed separately or blended with wet bran to generate wet or dry corn gluten feed (CGF). Its moderate protein content, relatively high energy content, and high digestible fiber content give CGF unique and versatile properties for feeding cattle.

CGF is most economical as a protein source because it may be substituted for costlier protein feeds as well as some grain for finishing beef. As a source of energy, the feeding value of CGF seems to vary. Because of its palatability, protein, and digestible fiber, it has high value for starting cattle on feed. Because of its high digestible fiber content, it is an excellent source of supplemental energy and protein for cattle consuming high-roughage feeds. Its value in the feedlot for finishing cattle is greater when it replaces grain as well as roughage.

The growing demand for fuel ethanol has resulted in widespread interest in smaller dry-mill plants producing ethanol with distillers grains (DG) and solubles (S) as co-products. Solubles can be condensed and dried or blended with DG to produce wet or dry distillers grains with solubles (DGS). Because of the high protein content of distiller products, they are used most commonly as sources of supplemental protein for

Table 1. Nutrient composition of corn processing co-products, dry basis.

Item	#2 Corn	Dry-mill ethanol			Wet milling		
		Wet distillers grains	Distillers solubles	Distillers grains with solubles	Wet CGF	Dry CGF	Condensed Steep water
Dry matter	88.00	28.00	5.00	Variable	44.00	90.00	57.00
Crude protein	10.00	23.00	30.00	25.00	21.00	20.00	23.00
Crude fiber	2.00	12.00	5.00	10.00	8.00	8.00	
NDF	10.00	44.00	23.00	44.00	38.00	42.00	
ADF	3.00	18.00	7.00	18.00	12.00	13.00	
Starch	71.00	14.00	22.00	16.00	22.00	20.00	
Fat	5.00	10.00	9.00	10.00	4.00	3.00	
Calcium	.02	.11	.35	.15	.10	.10	.14
Phosphorus	.35	.43	1.37	.71	1.00	.90	1.80
Potassium	.34	.18	1.80	.44	1.50	1.60	2.40
Sulfur	.14	.40	.40	.40	.40	.35	.59
MEm, Mcal/lb.	1.02	1.00	1.00	1.00	.98	.90	
Neg, Mcal/lb.	.70	.69	.69	.69	.67	.63	

Table 2. Feedlot performance of steers fed urea, soybean meal, or wet distillers grains as sources of supplemental protein[a].

	Supplement		
	Urea	DG	Soybean meal
Feedlot[b]			
Gain, lb. /d	1.43	1.91	1.96
Feed intake, lb. /d	13.50	14.20	16.20
Feed/gain	9.51	7.48	8.26
Chemical analysis of supplemental protein[c]			
Dry matter, %		21.5	90.3
Crude protein, %		28.5	48.7
Protein degraded, %		57.0	76.2

[a]Iowa State University, 1981.
[b]Composition of diets was: **Urea** - ground cobs 63%, cracked corn 20.8%, urea 2.3%, cane molasses 12% and supplement 1.9%; **DG** - ground cobs 63%, cracked corn 6.7%, cane molasses 12%, DG 15.3%, urea 1.3%, and supplement 1.7%; and **soybean meal** - ground cobs 63%, cracked corn 8.6%, cane molasses 12%, soybean meal 15%, and supplement 1.4%. Twenty head of Charolais steers (492 lb. .) were fed each of the three diets for 168 days.
[c]Protein degradation estimated from *in vitro* experiments in which feeds were incubated with rumen bacteria.

cattle. Because of their high fat and relatively high digestible fiber contents, DG also can be used as a source of energy for growing and finishing cattle.

The purpose of this paper is to review the options of using these co-products of corn processing as feed for cattle.

Nutritional characteristics of co-products

The chemical composition of the co-products is compared with corn grain in Table 1. The wet-milling process removes starch, oil, and some protein, leaving about 12 lbs. of dry matter in corn gluten feed per bushel of corn. The remaining nutrients, therefore, are concentrated in corn gluten feed. Wet CGF contains pieces of hulls from the corn kernels and is a relatively coarse feed. Dry CGF is usually ground and pelleted. In the dry-mill ethanol plants, corn is finely ground before starch is removed by fermentation, leaving the remaining nutrients concentrated in 15 to 16 lbs. of dry matter in co-products per bushel of corn. Particle size of distillers co-products is small because of the initial grinding of corn.

Moisture. Dry matter in the co-products can vary from 5% (distillers solubles) to more than 90% (dried products). Processing plants have the option of drying the co-products or selling them wet. Drying increases costs at the processing plant, but results in increased shelf life and reduced cost of transportation and provides more marketing opportunities for the co-products. Selling wet reduces storage time, increases transportation costs, and necessitates adequate on-farm storage facilities for the co-products, and requires ample numbers of cattle within a close proximity of the plant to utilize the co-products. As will be discussed later, the wet feeds have somewhat greater feeding value. Part of the benefit of the wet feeds is addition of moisture to dry feeds. Cattle respond to the addition of water to dry diets.

Crude protein. Protein is concentrated two to three times in the co-products compared with corn grain, so all the co-products are relatively rich sources of crude protein for supplementing cattle diets.

The insoluble protein fractions in corn are retained in the DG fraction, which results in significant quantities of slowly degraded proteins for ruminants. In Table 2, wet DG with soybean meal is compared with urea as a source of supplemental nitrogen for young steers. Rates of gain were similar for steers fed DG and soybean meal but greater than those of steers fed urea. Feeding soybean meal increased feed intake more than feeding DG, so feed efficiency of steers fed DG was superior to that of steers fed urea or soybean meal. Less of the total crude protein was degraded in DG compared with degradation of proteins in soybean meal (Table 2).

Considerable research has been reported using wet and dry DG and DGS as protein supplements for cattle. It appears that DG are equal in value to soybean meal in meeting the total supplemental protein requirements of growing and finishing cattle. Because the proteins in DG are less degradable than those in soybeans, the protein from DG is used more efficiently to provide proteins escaping the rumen.

Corn gluten feed is not a good source of undegradable protein for cattle, because the insoluble proteins are removed in the wet milling process. The value of dry CGF as a source of protein for growing cattle is summarized in Tables 3 and 4. Large-frame steers fed either CGF or soybean meal gained faster than those fed urea (Table 3). Rates of performance improvement of cattle fed this diet supplemented with CGF fell between the response to urea and

Table 3. Feedlot performance of steers fed dry corn gluten feed, urea, or soybean meal as protein supplement[a,b].

	Supplement		
	CGF	Urea	Soybean meal
Gain, lb. /d	2.06	1.74	2.50
Feed intake, lb. /d	17.30	16.30	18.20
Feed/gain	8.44	9.42	7.29

[a]Iowa State University, 1986.
[b]Composition of diets was: **CGF** - ground cobs 50%, cane molasses 10%, dry CGF 38.54%, urea .37%, and supplement 1.09%; **urea** - ground cobs 50%, cracked corn 36.7%, urea 1.97%, and supplement 1.33%; and **soybean meal** - ground cobs 50%, cracked corn 25.46%, soybean meal 13.54%, and supplement 1.0%. Twenty-seven head large-frame steers (715 lb.) were fed each diet for 41 days.

Table 4. Feedlot performance of steers fed urea, dry corn gluten feed, or dry corn gluten feed with soybean meal as protein supplement[a,b].

	Supplement		
	Urea	CGF	CGF+SBM
Gain, lb. /d	2.37	2.93	3.10
Feed intake, lb. /d	17.10	19.50	18.70
Feed/gain	7.25	6.68	6.06

[a]Iowa State University, 1987.
[b]Composition of diets was: **urea** - ground cobs 45%, cane molasses 10%, urea 2.0%, and supplement 1.8%; **CGF** - ground cobs 45%, cracked corn 13.2%, cane molasses 10%, dry CGF 30%, urea .8%, and supplement 1.0%; **CGF+SBM** - ground cobs 45%, cracked corn 8.9%, cane molasses 10%, dry CGF 30%, soybean meal 5.0%, urea .2%, and supplement .9%. Twenty large-frame steers (690 lb.) were fed each diet for 77 days.

Table 5. Feedlot performance of steers fed alfalfa haylage with two levels of corn and dry corn gluten feed and effects of supplements on digestibility by young bulls[a].

		Corn, % diet DM		Corn, % diet DM	
		20	60	20	60
Alfalfa haylage, %	**100**	**80**	**40**	**80**	**20**
Growth trial[b]					
Gain, lb. /d	2.42	2.86	3.96	3.08	3.74
Feed intake, lb. /d	23.30	23.80	27.70	24.40	26.60
Feed/gain	9.30	8.10	7.00	7.90	7.20
Digestion trial[c]					
Organic matter, %	52.00	56.80	60.10	57.90	71.40
NDF, %	52.00	55.90	58.10	57.00	69.30
ADF, %	45.40	45.30	44.80	46.60	50.90

[a]University of Missouri, 1988.
[b]Conducted with 780-lb. crossbred steers over 84 days.
[c]Conducted with 600-lb. Simmental bulls using indigestible acid detergent fiber as digestion marker.

Table 6. Digestibility of fescue pasture by grazing steers supplemented with corn or dry corn gluten feed[a,b].

	Supplement		
	0	Corn	CGF
Intake, lb. /d			
Forage	14.1	11.1	12.1
Supplement			
Digestibility, %			
Forage	48.0	38.8	46.9
Forage + supplement	48.0	54.7	56.2
Grazing, hr/d	7.8	4.2	5.9

[a]University of Missouri, 1987.
[b]Five yearling steers (640 lb.) per group grazing tall fescue during the last three weeks of August.

soybean meal.

In a second trial with large-frame steer calves, replacing part of the corn and urea with dry CGF improved gain and feed efficiency. Supplementing the diet containing CGF with soybean meal resulted in a slight improvement of performance (Table 4). These results indicate that proteins in dry CGF have nutritional value superior to that of urea but somewhat inferior to that of soybean meal. Wet CGF would have no greater value than dry CGF as a source of supplemental protein for cattle.

Fat. Oil originally present in corn is retained in DG but not in CGF. The 10% fat in DG should increase its energy value compared with corn. Recent cattle-feeding experiments at Nebraska suggest that wet DG with solubles have a higher energy value than dry rolled corn. The superior feed conversion of steers fed DG compared with soybean meal (Table 4) suggests that the fat in DG was well-utilized.

Fiber. Fiber is not removed by the milling processes, and its concentration compared with corn grain is increased in the co-products. Because the acid detergent fiber (ADF) concentrations are low compared with many forages, the fiber in the co-products is very digestible in ruminant diets. The results of supplementing steers fed alfalfa haylage with dry CGF or corn are summarized in Table 5. When 20% CGF was compared with 20% corn, CGF tended to improve feed intake, gain, and feed conversion. At 60%, corn was somewhat superior to dry CGF. The digestibility of organic matter and the fiber fractions were greater for the diet containing 60% CGF.

Intake and digestibility of tall-fescue pasture by grazing steers supplemented with pelleted corn or dry CGF is summarized in Table 6. These results show that forage intake and time spent grazing were not affected as adversely by supplementing with dry CGF as with corn. Digestibility of the forage was not depressed as it was when supplemented with corn. We interpret this to mean that CGF, being a high-fiber feed, does not cause a negative associative effect on digestion of forages as corn often does. No comparable studies have been reported on using DG as supplemental energy for grazing cattle or cattle fed high-forage diets.

Ruminants require fiber in the diet to maintain a healthful environment in the rumen. Both wet and dry CGF can furnish the fiber needed in finishing diets (see Tables 7 and 8). No studies have been reported in which DG replaced roughage in cattle diets.

Energy. The energy values of the co-products for feeding cattle are nearly equal to corn grain, even though most of the starch is removed from the raw

Table 7. Performance of finishing steers fed three levels of dry corn gluten feed by replacing corn and roughage in the diet[a,b].

	Dry CGF, % diet DM			
	0	30	45	60
Corn silage, % DM	21.30	10.60	5.30	0.00
Gain, lb. /d	3.12	3.39	3.03	3.13
Feed intake, lb. /d	21.30	22.80	21.70	21.50
Feed/gain	6.83	6.73	7.21	6.87
Dressing percentage	63.30	63.20	64.00	63.70
Percent Choice	94.40	94.40	88.90	94.40
Yield grade	2.50	2.39	2.39	2.39
Livers condemned, %	5.60	16.70	0.00	22.20

[a]Iowa State University, 1987.
[b]Eighteen steers per treatment. Control diet contained 89% cracked corn and supplement. Initial weight of steers was 740 lb. Steers fed 188 days.

Table 8. Performance of finishing steers fed three levels of wet corn gluten feed by replacing corn and roughage in the diet[a,b].

	Wet CGF, % diet DM			
	0	30	45	60
Corn silage, % DM	21.30	10.60	5.30	0.0
Gain, lb. /d	3.12	3.22	3.12	3.09
Feed intake, lb. /d	21.30	21.40	20.50	19.6
Feed/gain	6.83	6.66	6.56	6.36
Dressing percentage	63.30	63.90	63.60	63.5
Percent Choice	94.40	88.90	100.00	100.0
Yield grade	2.50	2.66	2.67	2.63
Livers condemned, %	5.60	11.10	5.60	22.2

[a]Iowa State University, 1987.
[b]Eighteen steers per treatment. Control diet contained 79% cracked corn and supplement. Initial weight of steers was 740 lb. Steers fed 188 days.

Table 9. Performance of finishing heifers fed two levels of dry corn gluten feed by replacing corn in the diet[a,b].

	Dry CGF, % diet DM		
Item	0	30	60
Cob, % dry matter	15.00	15.00	15.00
Gain, lb. /d	2.04	2.32	1.80
Feed intake, lb. /d	16.90	19.40	20.80
Feed/gain	8.27	8.80	11.69
Dressing percentage	60.70	61.20	59.70
Percent Choice	87.50	86.70	100.00
Yield grade	1.92	2.00	1.80
Livers condemned, %	6.20	6.70	6.70

[a]Iowa State University, 1986.

[b]Fifteen heifers per treatment. Control diet contained 85% cracked corn, molasses, and supplement. Initial weight of heifers was 760 lb. Heifers fed 90 days.

Table 10. Performance of finishing heifers fed two levels of wet corn gluten feed by replacing corn in the diet[a,b].

	Wet CGF, % diet DM		
	0	30	60
Cob, % dry matter	15.00	15.00	15.00
Gain, lb. /d	2.04	2.42	2.03
Feed intake, lb. /d	16.90	19.80	19.70
Feed/gain	8.27	8.20	9.97
Dressing percentage	60.70	59.80	59.70
Percent Choice	87.50	93.30	86.70
Yield grade	1.92	2.00	2.00
Livers condemned, %	6.20	0.00	0.00

[a]Iowa State University, 1986.

[b]Fifteen heifers per treatment. Control diet contained 85% cracked corn, molasses and supplement. Initial weight of heifers was 760 lb. Heifers fed 90 days.

grain. The fiber remaining in the co-products is highly digestible, resulting in feeds with relatively high energy values. In some situations, the available energy may be greater in the co-products because of the higher concentration of oil in distillers grains and because fibrous co-products have no negative associative effect on digestion of other fibrous feeds in the diet.

Studies at Iowa, Nebraska, Illinois, and Ohio indicate that wet CGF has an energy value slightly lower than corn for finishing cattle and somewhat higher than corn for growing cattle fed high-roughage diets. Dry CGF has somewhat lower energy value than the wet feed (compare feed efficiency of heifers fed 30% wet or dry CGF in Tables 9 and 10). Increasing the amount of CGF fed from 30% to 60% without reducing the roughage in a diet containing 15% ground cobs resulted in poorer gains and feed efficiency of finishing heifers (Tables 9 and 10).

In subsequent studies, replacing corn and roughage with wet or dry CGF has allowed feeding of greater amounts of CGF to finishing steers without reducing performance of finishing cattle (Tables 7 and 8). Other researchers have fed as much as 80 to 90% CGF in the diet without reducing roughage, but the control diets have contained less fiber than used in the experiment shown in Tables 9 and 10. Many cattle-feeding trials have been conducted at Iowa State University by feeding 45 to 60% of diet dry matter as wet or dry CGF (up to 90% of diet dry matter as wet CGF) with no other source of roughage; no digestive disorders or deaths have occurred. Research from several states has confirmed that up to 90% of diet dry matter for finishing cattle can be CGF with no significant change in performance. The quantity of CGF that can be fed is not limited by its chemical or physical nature, but should be determined by its cost compared with alternative feeds.

A 1984 summary of research done by Midwestern universities indicated that DG have energy values similar to corn. Recent studies at Nebraska indicate that wet DG have energy values significantly greater than corn (Table 11). Steers fed wet DG had improved gain and feed utilization compared with those fed dry rolled corn.

The energy values of the co-products listed in Table 1 probably are conservative for high-quality wet co-products. Using these values may result in underestimation of the economic value of co-products used as cattle feeds.

Minerals. Distillers grains and corn gluten feed have high concentrations of phosphorus and low concentrations of calcium. Corn gluten feed is also a good source of potassium. Both co-products have somewhat high concentrations of sulfur, which may result in thiamin deficiency with some diets or in locations with high sulfur concentrations in water. Supplementing diets containing co-products with thiamin is not necessary in all cases, but it may be prudent to consider routine thiamin supplementation of diets containing more than 20% co-products. Attention must be given to mineral balance in cattle diets containing these co-products. Supplemental phosphorus should be removed from the diet, and adequate calcium must be added to balance the high phosphorus content of co-products and prevent the occurrence of urinary calculi.

Table 11. Performance of finishing calf and yearling steers fed distillers coproducts[a,b].

	Co-product level, % diet DM			
	0	5.2	12.6	40.0
Feed intake, lb. /d				
Yearlings	25.2	24.6	24.0	21.3
Calves	18.5	19.2	18.6	17.4
Gain, lb. /d				
Yearlings	3.61	3.76	3.85	3.85
Calves	2.86	3.06	3.08	3.21
Feed/gain				
Yearlings	6.94	6.62	6.33	5.78
Calves	6.45	6.33	6.10	5.65

[a]University of Nebraska, 1993.

[b]All diets contained 5% corn silage and 5% alfalfa hay as roughage. The control diet contained 79% dry rolled corn, 5% molasses, and 6% supplement. 5.2% DGS replaced the crude protein from soybean meal in the supplement, 12.6% replaced crude protein from soybean meal and urea. Distillers solubles and DG were fed in proportion to those produced by the ethanol plant and were mixed in the complete diet of the cattle fed the two low levels. Cattle fed 40% DG were given the solubles as a source of drinking water until required volume was consumed and then allowed access to water. There were 40 yearlings and 40 calves for each of the treatments.

Feeding options

Many experiments have been conducted to evaluate the use of corn processing by-products as feed for cattle. All the experiments with adequate controls have been summarized by calculating the change in feed intake, gain, and feed efficiency of cattle fed co-products compared with control animals. The results for growing or finishing cattle and kind of co-product are represented graphically in relation to quantity of co-product fed (Figures 1 and 2). These data vary considerably because of differences in cattle and feeds used in the experiments, but trends become apparent as the quantity of co-product fed is increased.

Growing cattle (Figure 1). Replacing corn or corn and roughage with dry CGF in diets for growing cattle resulted in significant increases in fed intake, some increase in gain, and a decrease in feed efficiency compared with control cattle (Figure 1A). Most of the negative changes observed occurred in feed efficiency when more than 40% dry CGF was fed.

Feeding wet CGF to growing cattle as a source of energy resulted in less increase in fed intake, greater increase in gain, and improved feed conversion compared with changes observed with dry CGF (Figure 1B). Most of the negative changes observed with feeding growing cattle wet CGF were associated with feed intake.

This summary indicates that over a wide range of diets and cattle, feeding CGF will result in positive changes in performance of growing cattle. This probably is the result of the higher energy value of CGF when fed with higher-roughage diets.

Feeding wet DG or DGS to growing cattle as a source of energy nearly always has resulted in decreased feed intake and a decrease in gain with diets contained more than 25% co-product (Figure 1C). Feed efficiency, however, was not depressed by feeding up to 60% wet co-product. Not shown in the figure is the high value of dry DGS as a source of protein for growing cattle.

Finishing cattle (Figure 2). Feeding dry CGF to finishing cattle resulted in increased feed intake and a trend for poorer gain and feed conversion (Figure 2A). These results indicate that dry CGF had a lower energy value than the feed being replaced. This may be caused by the small particle size of dry CGF, resulting in a faster rate of passage of the feed through the digestive tract and poorer digestion. These results indicate that the quantity of dry CGF fed in most cattle finishing diets should be 30% or less.

Though the trend lines indicate a decline in performance when higher levels of wet CGF were fed as a source of energy, most of the changes in performance compared with the control diets without CGF were positive, especially when less than 50% of the diet was CGF (Figure 2B). These data suggest that cattle performance would not be significantly compromised by feeding up to 60% of the diet as wet CGF. Cattle were fed low-roughage diets in most of these experiments. Based on the results shown in Tables 8 and 10 and the observation that wet CGF seems to be an effective source of fiber, it appears that sources of fiber other than CGF should be reduced to maintain performance with high concentrations of CGF are fed.

Replacing corn or corn and roughage in finishing diets with CGF did not affect dressing percentage, percent of carcasses grading choice, or yield grades (Tables, 7,8,9,10 and 12). Feeding moderate to high concentrations of wet CGF to finishing steers had no effect on body composition or sensory quality of the muscle tissue (Table 12).

Feeding wet DG or DGS to finishing cattle nearly always has resulted in decreased feed intake but improvements in gain and feed efficiency (Figure 2C). Very few negative effects on gain or feed efficiency have been reported from feeding up to 50% of this co-product in the diet. The Nebraska researchers reported that feeding up to 40% of the diet dry matter as DGS increased gain (Table 11), but had no effect on dressing percentage or carcass quality. Too little research has been conducted to establish the effectiveness of the fiber in CG for stimulating rumen function. The current recommendation would be to feed 8 to 15% of the diet as roughage and replace corn and protein supplements with CG.

Starting cattle on feed. Feeders using set CGF have learned that cattle can be taken to the final finishing diet in less time and with fewer digestive upsets if they are started on CGF, and roughage and corn gradually are added to the diet. New feeder cattle readily consume wet CGF because of its palatability.

Table 12. Performance and carcass characteristics of yearling steers fed 0, 30, 50, or 90% of diet dry matter as wet corn gluten feed[a,b].

	Wet CGF, % diet DM			
	0	30	50	90
Cob, % dry matter	18.00	12.00	7.90	3.21
Gain, lb. /d	3.39	3.38	3.35	21.10
Feed intake, lb. /d	21.70	21.10	20.60	21.10
Feed/gain	6.39	6.26	6.15	6.58
Dressing percentage	58.00	59.90	59.40	59.20
Percent Choice	72.20	83.30	83.30	100.00
Yield grade	2.38	2.50	2.22	2.47
Carcass composition[c]				
Bone, %	18.50	19.00	18.40	18.50
Lean, %	56.30	56.20	56.30	56.10
Fat, %	25.90	26.70	26.60	26.80
Sensory evaluation[d]				
Tenderness	6.20	6.05	6.28	6.11
Juiciness	6.00	6.02	6.12	5.85
Flavor	5.97	6.07	6.06	5.79
Overall	6.08	6.17	6.18	6.02

[a]Iowa State University, 1988.
[b]Eighteen steers per treatment. Control diet contained 82% cracked corn and supplement. Initial weight of steers was 780 lb. Steers fed 136 days.
[c]The 9-10-11 rib sections were physically separated into fat, lean, and bone to estimate carcass composition.
[d]The 12th rib section was used for sensory evaluation by a ten-member trained sensory panel using an eight-point scale, with 1 being extremely tough, dry, off flavor, or unpalatable and 8 being extremely tender, juicy, flavorful, or palatable.

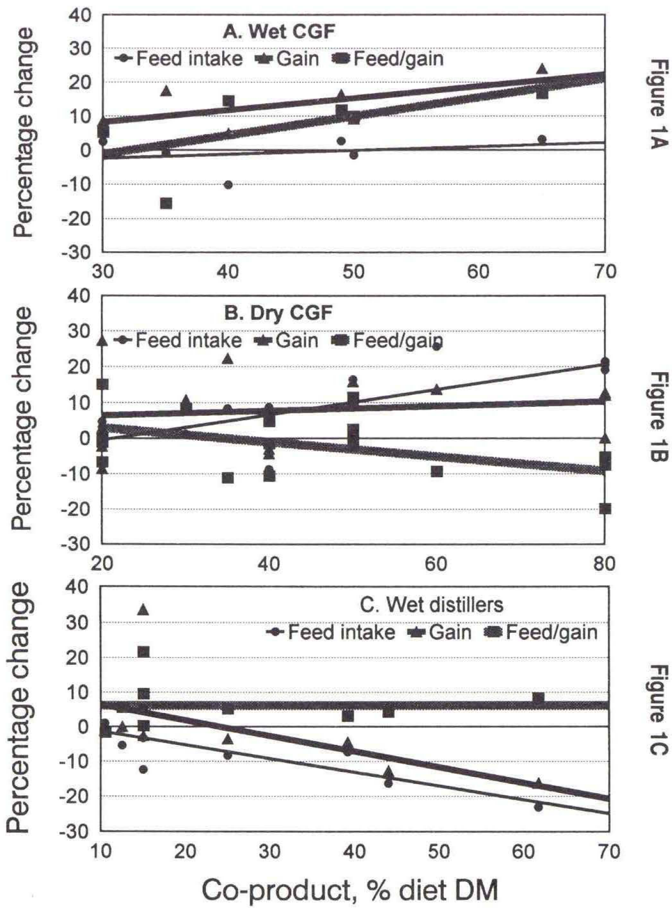


Figure 1. Effects of feeding growing cattle corn processing co-products on feed intake, gain, and feed efficiency.

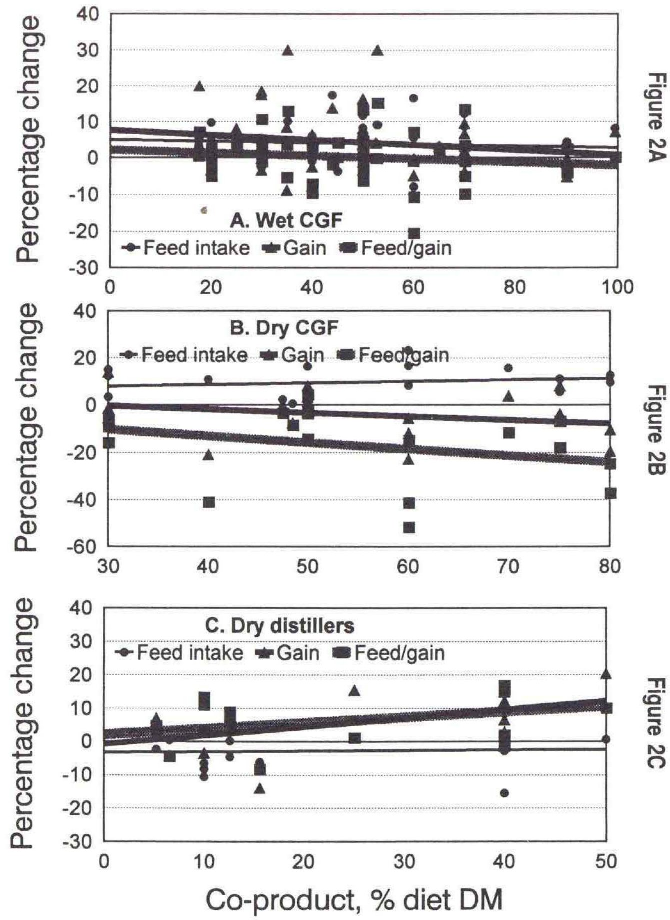


Figure 2. Effects of feeding finishing cattle corn processing co-products on feed intake, gain, and feed efficiency.

It is a high-energy feed, but is relatively safe for starting cattle because of its high fiber and low starch contents. Researchers at the University of Nebraska reported that cattle challenged with dry-rolled corn had greater time with rumen pH levels below 6 compared with cattle fed wet CGF. Apparently, feeding CGF reduces the severity of ruminal acidosis. A practical strategy might be to start new cattle on high levels of wet CGF and gradually adding corn to the desired proportion in the final finishing diet.

Creep feed for calves. A number of cattle producers have reported successful use of dry CGF in self-fed creep feed for nursing calves on pasture, but no research data have been reported. The results with grazing steers in Table 6 support the concept the using CGF as a creep feed for grazing calves.

Supplement for mature cows. The corn processing co-products are nearly ideal supplements for mature cows grazing or consuming mature forage of crop residues, because of their digestible energy content, high protein, high phosphorus, and lack of negative associative effects on digestion of fibrous feeds. Corn gluten feed is being used to supplement cows, but no extensive research has been reported.

Economic value of co-products as cattle feeds

A single equation will not establish the economic value of corn processing co-products for their many possible uses as cattle feed. All the co-products will have greater value when used up to a level that will meet the supplemental protein needs of the animal. The amount needed to provide protein will vary with diet, kind and age of cattle, and rate of gain. Value of the co-products will be lower when they are fed at a level greater than that needed to provide protein. CGF will tend to have greater value when fed with roughage, because it does not have negative associative effects on fiber digestion compared with corn grain. Dry CGF can have high economic value when fed to beef cows to supplement crop residues, compared with the cost of harvested hay.

The following equations have been developed for CGF fed to finishing cattle:*

1. When adding CGF to diets at a level to provide supplemental protein, it should comprise 25-30% of dry matter:
   (5.0 + 28.8 x corn price per bu. + 0.3 x SMB price per ton) x DM or CGF = Value CGF ($/ton)
2. When adding CGF at a level above 30% of diet dry matter:
   (6.1 + 37.8 x corn price per bu.) x DM of CGF = Value of CGF ($/ton)

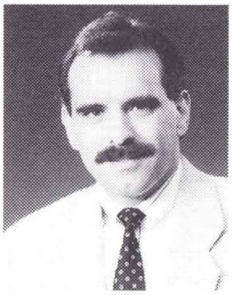
*These equations would be the value of CGF at the feedlot and should include transportation costs and storage losses. Corn prices should include processing costs and storage losses.

The values of the corn processing co-products usually fall within a range of 110-150% that of corn grain when compared on an equal moisture basis.

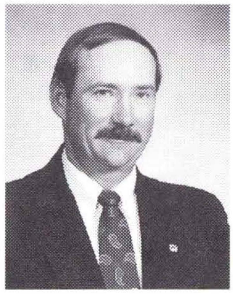
Implications

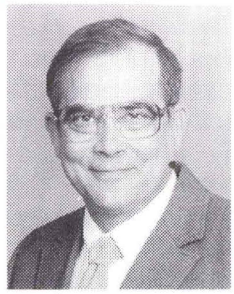
As the demand increases for ethanol, starch, corn sweeteners, and future products to be made from fractions of corn grain, production of CGF and DG will increase. To minimize production costs, more of these co-products will be marketed wet. Available research shows that these co-products are adaptable to many different cattle feeding situations and that the wet feeds are superior to the dry feeds.

Coordinative building of corn processing plants with cattle feeding operations has the potential of benefiting agriculture and rural development in Iowa. The corn processing plant can provide cattle feeders with a highly nutritious and versatile feed that can improve cattle production and lower feed costs. At the same time, cattle feeding can provide a readily available local market for a wet co-product, resulting in lower production costs for the processing plant. Nearly all cattle producers in Iowa produce corn, so they have a shared interest in the corn processing plant as a market for corn as well as a source of feed for cattle that also will return many of the nutrients in corn grain back to the farm. The corn processors and cattlemen should recognize this as an opportunity for a shared endeavor to benefit both parties. Success of these shared ventures will result in ancillary jobs that will enhance the economics of the local communities.


Anderson


Cooper


Clause


Greig

Feeding Corn Co-Products

Compiled by Dan Loy
Iowa State University
Extension Beef Specialist

The following is a summary of a questionnaire sent to members of a panel discussion prior to the conference. They were: Dr. Martin Anderson, Beef Technical Services Manager for Vita Plus Corporation, Madison, Wis.; Junior Cooper, owner and manager of Corn Beef Feedlot, Dike, Ia.; Reg Clause, owner and manager of Clause Feedlots, Grand Junction, Ia.; and John Greig, owner and operator of Greig & Co. Feedlot in Estherville, Ia. A questionnaire also was sent to Olin Cox, Cox Nutritional Services, a private nutritional consultant from Paton, Iowa.

These producers and nutritionists are experienced with corn gluten feed (wet and dry), wet distillers grains with solubles, corn screenings, hominy feed, and distillers dried grains. Many of the following comments relate to all of the above ingredients; wet corn gluten feed, however, represents by far the most utilized product. Loy's comments summarize each section.

Analysis and quality control

Anderson: Moisture, color, protein and appearance are monitored.

Cooper: The above, plus odor. Old gluten feed that has an off odor is rejected.

Clause: We are interested in getting some consistency in protein and moisture, primarily. General issues such as "freshness" do not seem to be a problem.

We understand that variability is to be expected in the ingredient market, but we believe that a given plant should be expected to offer some level of consistency in their day-to day-production. With the wet product, the methods of adding liquid to the material can have an effect on consistency. Therefore we see it as a plant management function that variability be kept to a minimum unless we are pricing out extraordinary material such as dryer spills, etc.

Cox: I recommend a comprehensive nutrient analysis when first starting on a new feed ingredient. Once the nutrient criteria have been established, periodic analyses should be make. Criteria should also be established as to what is "normal" for a particular feedstuff in terms of physical characteristics such as color, smell, moisture, consistency, etc. Inventory control becomes critical. Keeping the feed fresh and rotating the inventory are important, as well as good housekeeping in the feed ingredient area.

Summary: Some variation is expected with these feed products. However, periodic testing allows for timely adjustments when necessary. Moisture and protein are the most frequently mentioned areas for which load-to-load variations may occur. In addition, an organoleptic evaluation (sight and smell) may be a tip that a load is different or unusual. A comprehensive feed test was suggested when starting to use a new feed product. This would include the same product from a different plant or source, as production methods may vary from plant to plant.

Special qualities

Cooper: Corn gluten feed is palatable and economical. Cattle start [more easily], stay on feed better, and maintain higher intakes with less roughage. [The feed] does not freeze in the winter and is easy to mix with other ingredients.

Clause: The level of soluble fiber is important to us. We can use gluten in a starting ration on stressed cattle with excellent results. The nutrient profile is nearly ideal for this situation. We can get the protein level high enough and it is all natural. We can get the energy density high enough while not [risking] acidosis or loose bowels. The cattle will eat the material readily, so we can get our vitamin/mineral premix package into them more reliably.

We like the gluten rations in severe Iowa winter weather. This is because of the dietary fiber we can maintain while keeping our energy levels high enough to get performance. Cold stress can be a problem in Iowa, but as a custom feeder I have to get good rates of gain and conversions. The co-products seem to give us an edge that can mitigate our weather disadvantage here in Iowa.

We see very consistent results in our kill data. Dressing percentage, grade, and cutability have been very good and very predictable, even in tough months like January and February. Perhaps the special qualities of the gluten here involve keeping cattle on feed at a very stable rate. We find bunk management to be a little easier. We can get more intake because of the moisture in the ration. Usually this relates to slightly higher dry matter intake as well.

The gluten is an alternative feedstuff that does keep your rations corn-based. Most feeders, even in corn deficit areas, have found that corn gets the best results in the yard and in the cooler. It is priced by its own dynamics, which can help control volatility in ration costs.

Cox: The majority of co-products enhance the palatability of the diets, particularly with ground hay rations. The higher fiber content of many of these feedstuffs allows a higher margin of safety in preventing acidosis with cattle on finishing diets. This also complements supplementation flexibility in formulating and delivering the mixed rations to cattle. It has been working well, especially when fescue hay is a major component of the diet. The wet corn gluten works particularly well in blending various ingredients and making ingredient transitions in different diet formulations

Summary: The highly digestible fiber content of corn gluten feed is useful in several production situations. Most often cited is the effect on starting new cattle and adapting them to high-concentrate rations. This property is also useful for adding energy to lower-quality forages without the depressing effect that grain can have on fiber digestion—sometimes called the "associative effect" of feeds. The moisture content of wet co-products can act as a ration conditioner if dry grains and forages are the basic ration.

Ration formulation

Cooper: We allow corn gluten feed to be used at a rate of up to 30% of the ration dry matter. The price and protein level determine the amount of corn gluten used in the ration. We also moisture-test the corn gluten to stay within a specific moisture level.

Clause: Currently we are using 24% wet gluten as fed in the finishing rations. We will at times use levels as high as 40% as fed. The decision is based on a convergence of two rationales. First is relative pricing. Corn is my base-pricing benchmark. All ingredients are compared to corn for the energy component. Also, we compare protein sources for their availability and pricing. Gluten also can be considered against prices for other dietary fiber sources.

The second rationale involves physical aspects of the ration, and how they relate to the cattle we are managing. We like the wet product because it enhances mixability and controls dust. When we are adding corn screenings or ground hay, dust can be a problem unless we have a moisture component.

The gluten-based rations are very attractive in the bunk, and sorting of the ration is not a problem.

Cox: This is a complex decision-making process. We evaluate our performance goals and criteria, ingredient pricing and availability, and seasonalities as well as the origin, condition, and quality of the cattle involved. We have the ability to least-cost and/or best-cost our ration formulations as well as forecast animal performance, costs of production, and marketing windows of opportunity to either protect equity or meet profit goals.

Summary: These cattle feeders and nutritionists are using corn co-products primarily as a protein source based on the levels indicated. The ration conditioning effects of the moisture and the unique characteristics of the soluble fiber are also considered, however. Feeds usually are referenced to corn as an energy source. No simple pricing formula is adequate because of the complexity of various rations and the characteristics that coproducts may bring to them. Experience, price comparisons with reference feeds, and production goals are the criteria for decision-making.

Special production systems

Clause: One unusual application of gluten was in a growing ration for bred heifers. In this case, we used ground corn stover mixed with wet gluten and a mineral balancer. The gain was projected at 2.20, and this goal was achieved almost exactly. This ration was extremely cheap and the cattle stayed in the desired condition. In this case, the gluten created an opportunity to add value to stover.

Cox: The liquid distillers requires the tanks to be insulated and the delivery pipes to have heat tape and be wrapped with insulation. There may be a distinct advantage to putting tanks and lines underground if the product is going to be used continuously.

We have been able to reverse our requirement for value-added ingredients in putting our diets together. Much of our supplementation is "low input" and handled in bulk rather than bag.

Summary: The University of Illinois has verified the observations noted in the heifer-growing program mentioned above. When cattle were fed in a limit-fed growing program with corn gluten feed as the primary protein and energy source, corn gluten feed was equal to or better than corn in energy value.

Nutritional problems

Cooper: You need to look out for polio (polioencephalomalacia, PEM). This can be managed by feeding less than 30% of the ration or [by] adding thiamin.

Clause: We formulate with extra thiamin and allow for the high phosphate level of gluten. I would recommend [that] a professional nutritionist be involved to ensure that all minimums are exceeded. By-product feeding is different enough that one can benefit from others' experience.

Cox: Know your supplier. Know the product you are using. Supplementation for diets using co-products is critical. Once an operation deviates from hay, grain, or silage, a professional formulator, nutritionist or consultant should be used. Most problems arise from not using the ingredients properly.

Scales on feed wagons and ration batching sheets will eliminate most problems. The technical problems should be handled by the formulator when the diets are being put together

Summary: The most commonly cited potential problem with corn co-products relates to elevated levels of sulfur or phosphorus. Both of these minerals are required by the animal but can create problems at excessive levels.

Phosphorus must be balanced with calcium such that the Ca:P ratio is 1:1 to 1.5:1. At ratios lower than this, urinary calculi ("water belly") can become a problem in feedlot steers. Sulfur levels in excess of 0.4% of the ration dry matter can reduce feed consumption and performance. In addition, these elevated sulfur levels can react with the bacterial production of thiamin in the rumen. The result of a thiamin deficiency is polioencephalamalacia, a nervous-system disorder. While this effect has been difficult to demonstrate in research, enough testimonial evidence has been given to justify supplementing with thiamin as a precaution.

Pricing/price management

Cooper: Ingredients are analyzed within a set of guidelines by solving a linear matrix for our finisher ration. A computer program is used for pricing.

Clause: We try to book supply when we see a need to control price and supply. We work with a broker who has been helpful in maintaining a pricing level we could work with consistently and not have to move in and out all the time. We believe in keeping our business flexible, but a consistent ration program is most desirable both from a performance standpoint and a budgeting standpoint. If you can commit to a program of feeding these types of ingredients, then you simply find ways to even out the volatility.

We try to "best-cost" our rations, which means we will look at an array of the things we have available. We try to work through inventories in a way that makes sense to us, and the gluten can add flexibility. Many times, if we let the computer run it might call for nearly all gluten [based] on price alone. We then would limit that ingredient and put minimums on the ones we need to have in the ration. Much of this is judgment. We learn what is a feasible ration to handle and always look for ways to build margin into the feeding program.

Cox: I use the on-farm ingredients to establish the pricing criteria. There may be ingredients that have to be fed in order to convert it to cash.

Managing the on-farm inventory comes first. The second consideration is what is available in the community and at what cost. Third, what commodities are available, will "price" in the diets, and be practical to use. Having a commodities broker available may prove helpful.

Many feedstuffs have seasonal pricing patterns. Rather than moving in and out of an ingredient, it may work well to "book" a product during certain times of the year. Scales become important in determining "shrinkage" for many of these ingredients.

I am a user of feedstuffs and commodities, not a "salvager" or "junk dealer."

Summary: Corn processing co-products appear to have a seasonal pricing pattern. Year to year pricing does not always follow that of competitive feeds such as corn grain or soybean meal. These feeders and consultants have adapted to this situation by allowing some flexibility in rations, and planning ahead for the use of co-products. Pricing opportunities may be short-lived and forward-pricing of supplies well into the future may be necessary.

Handling/storage

Anderson: Best is flat storage—cement floor, covered if possible!

Cooper: Gluten is stored on a concrete floor in our silage bunker.

Clause: We have added a concrete holding area large enough to accommodate two semi-loads of wet gluten. This helps control the shrink and allows for thorough cleanup and rotation of inventory. We get one 25-ton semi-load at a time, but the additional space allows for receiving the next load before the first is gone. We like to have a neat feed-handling area and one that is easy for the trucker. It must be solid and fairly level on the approaches to the pad.

We have a long-term relationship with the trucker we use. This has given us the ease of communication and reliability that are necessary for a system that is nearly a just-in-time inventory. If we need to lay in extra supplies or aren't using product quickly enough, we will cover the pile. The truck dumps a very neat windrow that can be easily covered with an inexpensive plastic sheet and a few tires for weight. This is a good strategy for controlling shrink and maintaining quality, especially in warm, rainy weather. The material has a low pH and will stabilize when tightly covered.

Cox: We usually handle our ingredients in semi-load quantities. We prefer using ingredient bays or flat storage for our inventories. We batch our rations using front-end loaders. We strive for flexibility and simplicity and batch the diets on a daily basis.

Summary: The common characteristics of these storage systems are that they are flexible, convenient, and provide the ability to capitalize on opportunities. New products from corn processing may vary in characteristics from those used today. Therefore, a storage and handling system that can be readily adapted to the changing nature of feedstuffs is important.

Conclusions

This has been an overview of how a few successful cattle feeders and nutritionists have adapted corn co-products (primarily corn gluten feed) into their feeding operations. Over the last 10 years, many Iowa livestock producers have incorporated wet corn gluten feed and other corn co-products into their operations. For many of these producers, this was their first experience in feeding a commodity other than homegrown grains and forages and commercial supplements.

The feed industry in Iowa has adapted by developing premixes and supplements specifically for corn gluten feed-based rations. In the future, as new products are developed from corn, new co-products will be available for livestock as well. These products will differ from those currently used and will present a new set of problems and opportunities. Those feeders who take advantage of these opportunities will need to establish quality control guidelines, develop a working relationship with suppliers, seek counsel from qualified nutritionists and consultants, and plan flexibility into their feeding operations as economic conditions change.

Livestock production is itself a value-added agricultural industry. The appropriate use of co-products from other value-added industries in livestock production is a logical extension of this concept.

Reprinted from: 1993 Minnesota Nutrition Conference

Feeding Wet Distillers and Gluten Feed to Ruminants

T.J. Klopfenstein and R.A. Stock
Department of Animal Science, University of Nebraska
Lincoln Nebraska

Introduction

Distillers dried grains plus solubles (DDGS) commonly have been used as protein sources for ruminants and non-ruminants. Gluten feed from the wet milling industry has been used to supply both energy and protein for ruminants. The production of DDGS and gluten feed is increasing as more ethanol is used for fuel.

Because drying requires fuel energy, feeding wet distillers by-products and wet gluten feed has been studied as a means of reducing this energy and economic cost. Perishability of the by-products and transportation costs are important considerations when feeding wet by-products.

Finally, the effects of drying on the nutritional value of DDGS continues to be debated (Van Soest and Sniffen, 1984; Britton et al., 1986; Chase, 1987; Klopfenstein, 1987; Van Soest, 1989; Weiss et al., 1989). Undoubtedly, severely damaged DDGS have lower feeding values (Klopfenstein, 1991), but these types of damage do not occur routinely. Criticism of heat damage in DDGS continues but may be unwarranted.

We have conducted a series of experiments to study 1) the feeding of distillers by-products as an energy source to feedlot cattle, 2) the effects of drying on the feeding value of distillers by-products, and 3) the feeding value of wet corn gluten feed.

Wet distillers by-products experiments

Because of the high moisture content, transportation of wet by-products is expensive and the by-products will mold readily. Therefore, it is necessary to feed wet by-products where a large concentration of cattle exists, such as in beef feedlots. Feeding distillers by-products in feedlot diets as a source of both protein and energy would encourage their rapid consumption.

Distillers by-products (wet grains and thin stillage) were produced at the University of Nebraska's farm-scale alcohol plant and transported every other day to the beef feedlot. Fermented corn mash was screened and pressed, separating the solids (wet grains) from the liquid. The liquid fraction was distilled, removing the alcohol and forming the by-product, thin stillage. For each distillation, the by-products were weighed, sampled, and measured for DM content. The ratio of wet distillers grains:thin stillage production (DM basis) was computed monthly and diets were altered accordingly. Samples were composited weekly and analyzed for CP. Trial composites were analyzed for DM, CP, starch, NDF, fat, ash, and ethanol.

In general, fermentation and distillation removed the corn starch, which concentrated the remaining nutrients (Table 1). The crude protein content of thin stillage produced in our plant (19%) was lower than typical values (26-29%). The wet distillers by-products (WDB) may not be typical of dry distillers grains and solubles produced from commercial dry milling plants. The WDB used in these trials contained more starch and ethanol and less protein than values reported in other literature for dry distillers grains plus solubles. In addition, the increased starch content of WDB suggests less starch was converted to alcohol than would be expected in normal commercial operations. The mean production ratio (DM basis) of wet distillers by-products (wet grains:thin stillage) during the yearling trials was 1.65:1, and 1.70:1 during the calf trials, compared to the mean feeding ratio of 1.67:1 and 1.81:1 for the yearling and calf trials, respectively. Dry matter content (includes ethanol) of the by-products was 31.4% (wet grains) and 5.0% (thin stillage) and was variable (wet grains mean coefficient of variation (CV) = 9.5%; thin stillage mean CV= 21.2%).

Two finishing trials were conducted, beginning in May of 1990 and 1991, using 80 crossbred yearling steers per trial (Year 1, body weight = 697 lb.; Year 2, body weight = 748 lb.). Steers were allotted randomly to eight pens (two pens/treatment/trial). Treatments consisted of a control and 5.2, 12.6, and 40.0% (of diet DM) WDB. The proportion of wet distillers grain:thin stillage was constant among WDB levels and based on the ratio of by-product production. All diets contained 5% corn silage and 5% alfalfa hay. The control diet contained 79% dry rolled corn, 5% molasses, and 6%

Table 1. Corn and wet distillers byproduct composition, % of DM[a].

Nutrient	Corn	Wet grains	Thin stillage	WG:TS[b]
Starch	70.3	9.0	22.0	13.9
Crude protein	10.1	25.0	16.8	21.9
NDF	10.9	39.4	11.7	29.1
Fat	3.8	13.7	8.1	11.6
Ash	1.4	1.4	5.9	3.1
Ethanol		10.7	12.2	11.3
Dry matter[c]	86.8	31.4	5.0	21.5

[a]Average of yearling and calf trials.
[b]WG:TS = 1.68 wet grains:1 thin stillage (production ratio), DM basis.
[c]Includes ethanol.

supplement. Supplemental protein for the control diet was a 50:50 combination (CP basis) of soybean meal and urea. The low level (5.2%) of WDB replaced the same amount of CP as supplied by soybean meal in the control diet. The medium level (12.6%) of WDB replaced the same amount of CP as supplied by soybean meal and urea in the control diet. The high level (40.0%) of WDB replaced all of the soybeans of CP and energy. Diets were balanced for 12% CP (40% WDB diet contained 15.5% CP), .70% calcium, .35% phosphorus, and .70% potassium and contained .25 g/ ton Rumensin(TM) and 10 g/ton Tylan (TM) (DM basis).

Steers were adapted to the final diets in 21 days using four step-up diets containing 45% (three days), 35% (four days), 25% (seven days), and 15% roughage (seven days; DM basis). Roughage was a mixture of corn silage and alfalfa hay with corn silage assigned a value of 50% roughage. Wet distillers grains were mixed in all diets; however, because of the high moisture content of thin stillage (95.5% moisture), thin stillage was mixed in diets containing 5.2% and 12.6% by-products and offered as the source of drinking water at the 40% by-product level. When steers had consumed their allotted thin stillage, water was available *ad libitum*. Cattle were implanted with Compudose(TM), fed once daily, and housed in an open-front confinement barn.

Two finishing trials were conducted, beginning in November of 1990 and 1991, using 80 crossbred steer calves per trial (Year 1, body weight = 603 lb.; Year 2, body weight = 615 lb.). Experimental treatments and procedures for the calves were the same as for the yearlings with the following exception: the calf control supplement contained soybean meal as the only supplemental protein source (no urea). The trial was initiated approximately 30 days after arrival at the feedlot, at which time the calves were implanted with Compudose(TM). Calves were fed for 194 and 181 days in 1990 and 1991, respectively. Adaptation to the final diets, feeding initial weighing procedures, and carcass measurements were performed as in the yearling trials.

Table 2. Effect of wet distillers by-product level on finishing performance of yearlings and calves.

	By-product level, % of diet DM[a]			
Item	**0**	**5.2**	**12.6**	**40.0**
Daily feed, lb.				
Yearlings[b]	25.21	24.64	24.05	21.30
Calves[b]	18.52	19.23	18.55	17.40
Daily gain, lb.				
Yearlings[c]	3.61	3.76	3.85	3.85
Calves[b]	2.86	3.06	3.08	3.21
Feed/gain[f]				
Yearlings[e]	6.94	6.62	6.33	5.78
Calves[b]	6.45	6.33	6.10	5.65

[a]Wet grains:thin stillage (fed ratio), yearlings = 1.67:1; calves = 1.81:1, DM basis.
[b]By-product level, linear (P<.01).
[c]By-product level, linear (P<.10); quadratic (P<.10).
[d]Feed/gain analyzed as gain/feed. Feed/gain is reciprocal of gain/feed.
[e]By-product level, linear (P<.01); quadratic (P<.10).
[f]Accounts for ethanol consumption.

Both yearling and calves responded similarly (Table 2) to WDB. No interactions (P>.1) between years in cattle performance were detected among WDB levels, therefore, data were pooled across years within yearling and calf trials. As the level of WDB increased, cattle consumed less DM (linear, P<.01), gained faster (linear, P<.1), and were more efficient (linear, P<.01) than the control cattle. Fat thickness at slaughter did not differ among treatments and averaged .53 inches for yearlings and .54 inches for calves. Liver abscess score was not statistically different among treatments; however, there were three severely abscessed livers from cattle fed the control compared to 0 for cattle fed 40% WDB. Quality WDB graded higher (linear, P<.01) than the control calves (0% WDB=68% choice, 40% WDB=93% choice).

Dry matter intake values would not account for ethanol intake because ethanol is volatized upon drying. Accounting for ethanol intake, yearlings were 5, 10, and 20% more efficient while calves were 2, 6, and 14% more efficient than the controls when fed 5.2, 12.6, and 40.0% wet distillers by-products, respectively. Calves were expected to benefit more from high levels of metabolizable protein than yearlings due to differences in composition of gain (more lean growth). However, metabolizable protein intake was above the calculated requirement for all treatments.

Improvements in yearling and calf performance at each level of wet distillers by-products can be attributed to increased energy utilization. The NE_g of each diet was calculated, based on performance, according to NRC (1984) equations (Table 3). The NE_g content of wet distillers by-products was calculated by substitution. Wet distillers by-products contributed 80, 62, and 47% more energy than corn when fed to yearlings and 17, 33, and 29% more energy than corn when fed to calves at 5.2, 12.6, and 40.0% of the diet DM, respectively. Compared to corn, WDB contained an average of 1.69 times more energy for gain of yearlings and 1.28 times more energy for gain of calves when included up to 40.0% of the diet (Table 3).

A combination of factors likely contributed to the high energy value of wet distillers by-products. First,

Table 3. Net energy content of diets and wet distillers by-products in yearling and calf trials, % of DM[a].

NE_g	0	5.2	12.6	40.0[b]
Diet, Mcal/cwt.[a]				
Yearlings	54.9	58.1	60.8	67.2
Calves	60.8	61.7	64.4	69.4
Wet Distillers, Mcal/cwt.[b]				
Yearlings		126.5	113.9	103.3
Calves		82.3	93.5	90.7
Feed/gain[f]				
Yearlings[e]		180	162	147
Calves[b]		117	133	129

[a]Based on cattle performance.
[b]Calculated by substitution.

the by-products contained more than three times more fat (corn oil) than corn (Table 1), although fat theoretically contains 3.5 times more metabolizable energy than corn grain, and ethanol contains 1.7 times more gross energy than corn. Secondly, cattle fed WDB consumed less starch and more corn fiber, which is highly digestible, than the control cattle. This may have reduced digestive problems (acidosis). The greater susceptibility of yearlings to acidosis may have contributed to the different energy values, relative to corn, of WDB between yearlings (average relative value = 169%) and calves (average relative value = 128%). Relieving subacute acidosis typically is associated with an increase in intake; however, because cattle eat to a constant energy level and the WDB contained more energy than corn, DMI was not increased (Tables 2 and 3). Thirdly, the use of bypass protein as an energy source may have reduced metabolic losses associated with microbial fermentation.

Table 5. Calf gains and protein efficiencies[a].

Supplemental protein	Daily gain[b], lb.	Protein efficiency[c]	Protein[d] escape	ADIN, % CP
Urea	1.00	—	—	—
Wet grains + thin stillage	1.46	2.55	54.9	—
Low-ADIN dried grains + solubles	1.42	2.00	38.0	9.7
Medium-ADIN dried grains + solubles	1.47	1.79	47.4	17.5
High-ADIN dried grains + solubles	1.54	2.50	49.4	28.8

[a]Intake averaged 2.3% (DM) of body weight.
[b]Averaged across levels of supplemental protein.
[c]Gain above urea controls divided by protein intake above urea controls (slopes of regression lines).
[d]Twelve-hr. dacron bag escape values, % of CP.

Wet vs. dry distillers by-products experiments

Two experiments were conducted to compare wet distillers by-products to DDGS as protein and energy sources. Wet by-products were produced as described previously. Eleven batches of dried by-products were obtained from commercial distilleries. Three composites were prepared on the basis of acid detergent insoluble nitrogen (ADIN); low, medium, and high.

For energy evaluation, 160 yearling steers (865 lb.) were fed diets of 5% corn silage, 5% alfalfa hay, 5% molasses, 6% supplement and 79% dry rolled corn. Distillers by-products replaced supplemental protein and corn to supply 40% of the diet dry matter. For the wet by-product, the thin stillage was consumed as the drinking water. This experiment was conducted similarly to those discussed previously.

The cattle fed the distillers by-products gained significantly faster than those on the control corn diet (Table 4). Cattle fed the DDGS ate more than the controls, while those fed the wet by-products ate less than the controls. Most importantly, feed efficiency was improved by feeding the distillers by-products compared to the control. The wet by-products tested significantly better than the DDGS. Wet by-products had 46% more energy than corn, and dried products 24% more. There was no effect of ADIN level in the DDGS on cattle performance when the DDGS were fed as an energy source.

Table 4. Energy value of wet vs. dry grains.

	Control	Wet	Low[a]	Medium[a]	High[a]
Daily feed, lb.	24.2[bc]	23.5[b]	25.3[c]	25.0[c]	25.9[c]
Daily gain, lb.	3.23[b]	3.71[c]	3.66[c]	3.71[c]	3.76[c]
Feed/gain	7.50[b]	6.34[c]	6.93[d]	6.74[d]	6.87[d]
Improvement:	.1333	.1577	.1444	.1484	.1455
Diet			18.3	9.6 (ave.)	
Distillers vs. corn			45.8	24.0	

[a]Level of ADIN, 9.7, 17.5, and 28.8%.
[b,c,d]Means in same row with different superscripts differ ($P<.05$).

For protein evaluation, 60 growing calves (449 lb.) were individually fed diets based on sorghum silage (31.7% of diet DM) and corncobs (50% of diet DM). The distillers by-products served as the bypass protein supplements, and a urea supplement served as a control. The distillers by-product supplements were combined with the urea supplement to provide increasing levels of protein from the distillers by-products (25, 34, 43, and 52% of supplemental protein). There were 12 calves on the urea control and 12 calves on each source of distillers by-products (three per level). The calves were implanted with Compudose(TM) at the beginning of the trial and were fed for 56 days. Weights were taken for three consecutive days at the beginning and end of the experiment. The diets were fed at an equal percent of body weight to all animals and the amount of orts was minimized. Data were analyzed using the slope-ratio technique.

The urea control cattle gained 1.0 lb./day (Table 5), and the cattle at the highest protein level gained 1.54 lb./day. No significant differences were observed in gains of the cattle averaged across protein levels. Cattle fed WDB tended to have higher protein efficiency values than those fed DDGS, but overall the differences were small and not significant.

No significant differences appeared in the protein efficiency values for the DDGS composites. Numerically, the protein efficiency values increased with ADIN level, indicating no heat damage. This supports prior research that suggests ADIN is a poor indicator of protein damage in protein supplements. Distillers by-products are good sources of bypass protein.

Drying appears to have very little effect on the value of the protein for growing calves. Distillers by-products can be fed wet or dry and equal protein value will be obtained.

Wet gluten feed experiments

Both wet and dry corn gluten feed have been researched primarily as energy sources (Green et al., 1987; Weiss et al., 1989). The protein in gluten feed is highly degraded so it is a relatively poor source of escape protein (DeHaan, 1983). While gluten feed contains a large amount of fiber and very little starch, the fiber is highly digestible and, therefore, the energy content of the gluten feed is quite high. Drying reduces the apparent digestibility of the fiber in gluten feed (Green et al., 1987), so feeding it wet has both nutritional and cost advantages. Because the primary energy-yielding nutrient in wet corn gluten feed (WCGF) is fiber, we have conducted a series of experiments to further evaluate WCGF as a source of energy in growing and finishing beef cattle diets.

A growing trial was conducted with 570-lb. calves. Wet gluten feed was compared to dry rolled corn in alfalfa and corn silage based diets. All diets contained a minimum of 11.5% CP, .45% Ca, .3% P, and 20 g/ton Rumensin(TM).

In finishing Trial 1, 735-lb. steers and 821-lb. heifers were fed diets of dry rolled corn and replacement corn with 35 or 70% WCGF. Dry gluten feed was fed as 70% of the diet in the fourth treatment, and water to equal that in WCGF was added to dry gluten feed in the fifth treatment. The sixth treatment was a combination of 70% WCGF and high-moisture corn. The final diets contained 5% corn silage, 5% alfalfa hay, 5% molasses, and 3% supplement; the remainder was grain or gluten feed. Diets were formulated to a minimum of 12% CP, 0.7% Ca, 0.3% P, 0.7% K, 25 g/ton Rumensin(TM) and 10 g/ton Tylan(TM) (DM basis). Cattle were implanted with Compudose(TM) and fed once daily. They were adapted to final diets using four grain-adaptation diets containing 45, 35, 25, and 15% roughage.

Finishing Trial 2 was conducted in a similar manner. The 836-lb. steers were fed WCGF at 17.5, 52.5, 70, and 87.5% (DM basis) of the diet replacing 20, 40, 60, 80, or 100% of the corn and molasses in the diet. Eight percent alfalfa was the only roughage fed, and 50 mg thiamine/hd/day was supplemented.

Table 6. Performance of cattle fed wet corn gluten feed (WCGF) in a growing trial.

	44% corn 50% alfalfa 5% molasses	49% WCGF 50% alfalfa	65% WCGF 33% alfalfa	33% corn 33% alfalfa 33% corn silage
Daily gain lb.[a]	2.62[b]	3.05[c]	3.36[d]	2.71[b]
DM intake, lb/day	20.53	21.09	21.06	20.40
Feed/gain	7.80[b]	6.89[c]	6.26[d]	7.51[b]

[a]Gains are based in final weights shrunk 3%.
[b,c,d]Means with unlike superscripts differ (P<.05).

Growing Trial

Calves fed 49% WCGF, 50% alfalfa hay gained 14% faster (P>.05) and 10% more efficiently (P>.05) than calves fed the two control diets (44% corn, 50% alfalfa hay or 33% DRC, 33% alfalfa hay, 33% corn silage) (Table 6). Increasing the level of WCGF to 65%, increased daily gain (P>.05) and feed efficiency (P>.05), but did not affect dry matter intakes. Calves fed 61% WCGF and 37% cornstalks or the grass hay and cob mixture gained more slowly (P>.05), but more efficiently (P>.05) than calves fed the control diets. However, caution should be used when evaluating cattle fed 61% WCGF and 37% cornstalks, because during the initial 68 days, the cattle readily sorted the cornstalks and consumed mostly WCGF. After cornstalks were replaced with grass hay and corncobs, dry matter intake increased 6 to 7 lb./day.

Gains were higher than expected for all treatments. The calves used in this trial were approximately nine to ten months of age and had been limit-fed for minimal daily gain (<.10 lb./day) the previous two to three months. Thus, the potential for compensatory gain was high. However, the feed value of WCGF appears to be high for calves fed growing diets.

Finishing Trial 1

Cattle fed the DRC control or the 70% WCGF + high moisture corn had similar daily gains, feed intakes, and feed efficiencies (Table 7). No statistical differences were observed for daily gain, feed intake, or feed efficiency among DRC control and 35% WCGF or 70% WCGF; however, cattle fed the 35% and 70% WCGF + DRC tended (P=.16) to be 5% less efficient than the DRC control. No differences in carcass characteristics (data not shown) were observed.

Cattle fed 70% DCGF consumed more feed (P<.01) and gained faster (P<.10) than all other treatments. Inclusion of water to the 70% DCGF reduced feed intake (P<.01) and daily gain (P<.10) but feed efficiency was similar for 70% DCGF and DCGF + H_2O. Wet corn gluten feed had a calculated (3.5% reduced efficiency ÷ an average 58.5% fed in the WCGF diets) feeding value of 94% relative to the value of corn.

Finishing Trial 2

Addition of WCGF did not affect feed efficiency; however, daily gain and feed intake showed a quadratic response (P<.05), indicating a positive

Table 7. Effect of wet and dry corn gluten feed on finishing performance.

	70% DRC[a]	35% WCGF[a]	70% WCGF	70% DCGF[a]	70% DCGF + H_2O	WCGF+ HMC[a]
Daily gain lb.[b]	3.20[cd]	3.17[cd]	3.08[d]	3.32[c]	3.01[d]	3.18[cd]
DM intake, lb./day	25.50[e]	26.58[e]	25.83[e]	29.49[f]	26.61[e]	25.39[e]
Feed/gain	7.96[g]	8.40[gh]	8.38[gh]	8.89[h]	8.81[h]	7.98[g]

[a]Gains are based in final weights shrunk 3%.
[b]Final weight calculated from hot carcass weight ÷ .62.
[c,d]Means with unlike superscripts differ (P<.10).
[e,f]Means with unlike superscripts differ (P<.01).
[g,h]Means with unlike superscripts differ (P<.05).

Table 8. Effect of level of wet corn gluten feed on cattle performance.

Item	DRCa Control	17.5% WCGF	35.0% WCGF	52.5% WCGF	70.0% WCGF	87.5% WCGF
Daily gain lb.[bc]	3.47	3.61	3.77	3.62	3.59	3.42
DM intake, lb./day[c]	23.01	23.79	24.04	23.93	22.91	22.73
Feed/gain[d]	6.60	6.57	6.37	6.62	6.38	6.65
NEG diet Mcal/cwt.[e]	63.50	63.50	65.20	62.90	68.40	63.30

[a]DRC = dry rolled corn; WCGF = wet corn gluten feed.
[b]Final weight calculated from hot carcass weight /.62.
[c]Level of WCGF, quadratic effect (P<.05).
[d]Feed/gain was analyzed as gain/feed, feed/gain is a reciprocal of gain/feed.
[e]Calculated from animal performance.

associative effect (Table 8). Maximum gain and intake were achieved when WCGF replaced 40% of the corn (35% of the diet DM). Feed intake and daily gain were increased 5.2% and 9.6%, respectively, at the 35% WCGF level, resulting in an increased feed efficiency of 3.9%. In high-grain finishing diets, increases in feed intake and daily gain are indicative of a reduction in subacute acidosis. Substituting a highly degradable fiber such as WCGF for starch (corn) appears to reduce subacute acidosis and increase efficiency when fed at approximately 35% of the diet DM. In addition, 35% WCGF minimizes sorting of dietary ingredients and eliminates the need for supplemental crude protein, phosphorus, and potassium—relatively expensive supplemental nutrients. Fat thickness, quality grade, and yield grade were not affected by the addition of WCGF.

The estimated NE_g content for the control diet, based on animal performance, was 63.5 Mcal/cwt., which is similar to the energy values for the ingredients listed in the 1984 NRC. The estimated NE_g for the WCGF diets was similar and ranged from 62.9 to 68.4 Mcal/cwt. (Table 8). Based on a corn NE_g value of 70.3 Mcal/cwt., the NE_g value of WCGF ranged from 66.9 to 75.6 Mcal/cwt. and averaged 70.3 Mcal/cwt. Therefore, the energy value of WCGF and dry rolled corn, in this trial, were equivalent and were not affected by level of WCGF fed in the diet.

During this trial (summer), a load of WCGF lasted approximately seven days. Heating of WCGF was minimal in the bunker; however, once the gluten feed was mixed and delivered to the bunk, some heating did occur, especially in diets containing the high levels of WCGF. Heating did not appear to affect palatibility or feed intake, however.

Literature Cited

Britton, R.A., T.J. Klopfenstein, R. Cleale, F. Goedeken, and V. Wilkerson. 1986. Methods of estimating heat damage in protein sources. Proceedings from the 41st Distillers Feed Conf., p. 67.

Chase, L.E. 1987. Heat damaged protein—why worry about it? Proceedings from the 42nd Distillers Feed Conf., p. 87.

Green, D., R. Stock, and T. Klopfenstein. 1987. Corn gluten feed—a review. *Nebraska Beef Cattle Report*, MP 52:16.

Klopfenstein, T.J. 1991. Efficiency of escape protein utilization. Proceedings of the 46th Distillers Feed Conf., p. 77.

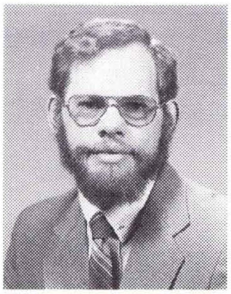
Klopfenstein, T.J. 1987. Heat damage—real or artifact? Proc. 42nd Distillers Feed Conf., p. 84.

Van Soest, P.J., and C.J. Sniffen. 1984. Nitrogen Fractions in NDF and ADF. Proceedings of the 39th Distillers Feed Conf., p. 72.

Van Soest, P.J. 1989. On the digestibility of bound N in distillers grains: A reanalysis. Proceedings of the Cornell Nutr. Conf., p. 127.

Weiss, W.P., D.O. Erickson, G.M. Erickson, and G.R. Fisher. 1989. Barley distillers grains as a protein supplement for dairy cows. *Journal of Dairy Science* 72:980.

Weiss, W.P. et al., 1989. *Corn gluten feed in beef cattle diets.* North Central Regional Research Publication No. 319, OARCD Special Circular No. 129, Wooster, OH.



Corn Gluten Feed for Dairy Cattle

Lee H. Kilmer
Extension Dairy Specialist, Iowa State University
Ames, Iowa

As profit margins continue to decrease, dairy producers have focused more attention on their feeding program because feed constitutes the largest single expense item (ranging from 40 to 60%) relating to the total cost of producing milk. However, other factors, such as labor, building and equipment costs, land values, taxes and depreciation also affect profit. Except for labor and feed, the costs of producing milk are fixed costs and cannot be changed much by an individual dairy producer. Consequently, development of an economical feeding program is a primary concern of most dairy producers. Development of a profitable dairy enterprise involves making nutritional and economical assessments of feedstuffs that are or will be utilized in the feeding program. Recent trends toward larger herd sizes and increased use of total mixed rations (TMR) have resulted in more dairy producers looking at various by-product feedstuffs, such as corn gluten feed (CGF), corn distillers grains, brewers grains and whole cottonseed.

Many feeding trials with wet (WCGF) and/or dry (DCGF) corn gluten feed have been reported in the past several years. Table 1 summarizes research results reported when WCGF and DCGF were fed to lactating dairy cows. In general, both products are excellent feeds for lactating dairy cattle, resulting in similar levels of intake and production of fat-corrected milk. The data indicate that up to 25-30% (dry matter basis) of either WCGF or DCGF can be incorporated into the diets of lactating dairy cows without any decrease in milk yield. Consequently, for many dairy producers, the decision regarding whether to incorporate CGF into the diets for their lactating dairy cows should be based on economics. This decision should consider the relative price of CGF compared to other available feedstuffs and the additional costs associated with storing, handling, and feeding WCGF or DCGF.

Few studies have reported growth and feed efficiency data for replacement dairy heifers (Table 2), although there have been numerous studies with steers (refer to other papers in this proceedings). The Illinois study (8) looked at WCGF, alflafa haylage and oatlage as the sole feedstuff fed to growing replacement dairy heifers in an 83-day feeding trial. Average daily gains were higher for heifers fed WCGF than for heifers fed other forages. The daily weight gains for the heifers fed WCGF exceeded current NRC recommendations, suggesting a predisposition to fattening. Thus, WCGF should not be offered as the only feedstuff for growing replacement dairy heifers.

Corn gluten feed is low in fat and starch, but high in digestible fiber. Because most of the starch has been removed, a higher rumen pH (less acidity) may occur, resulting in a reduction in rumen acidosis and incidences of cows going "off-feed." Also, the relatively high neutral detergent fiber and lower acid detergent fiber level means that there is a high percentage of hemicellulose which is highly digestible. Thus, many of the trials with lactating dairy cows demonstrated an increased percentage of milk fat in cows receiving CGF. Corn gluten feed usually contains more than 20% crude protein (CP) and the protein is relatively soluble (> 60%). For diets characteristically low in fiber and protein, but high in starch, such as those based on corn and corn silage, CGF appears to be a viable alternative. Corn gluten feed is finely ground, suggesting a high rate of passage and reduced digestibility. Drying CGF reduces digestible fiber and degradable protein, while increasing the percentage of undegraded intake protein (UIP). However, if excess heat is used in the drying process, the DCGF will be darker in color and a portion of the protein may be heat-damaged. A darker WCGF, however, is an indication that more corn steep liquor has been added, resulting in a higher level of protein in the feed.

Table 1 summarizes results of numerous studies, listed in the references on page 56. The table begins on page 54.

Table 1. Results of feeding wet (WCGF) or dry (DCGF) corn gluten feed to lactating dairy cows.

Reference (9).	% WCGF 0	% WCGF 18.6	% WCGF 37.1	
First lactation				
Dry matter intake (lb)	33.90	35.40	34.80	
Milk yield (lb)	47.10	46.60	45.30	
Milk fat (%)	3.76	3.78	3.97	
Milk protein (%)	3.17	3.19	3.11	
Reference (9).	**% WCGF 0**	**% WCGF 18.6**	**% WCGF 37.1**	
Older cows				
Dry matter intake (lb)	44.20	41.60	40.00	
Milk yield (lb)	72.20	66.40	64.50	
Milk fat (%)	3.48	3.50	3.62	
Milk protein (%)	3.09	2.98	2.94	
Reference (9).	**% WCGF 0**	**% DCGF 26.0**	**% WCGF 26.0**	
Dry matter intake (lb)	38.30	42.20	36.30	
Milk yield (lb)	57.40	59.20	53.20	
Milk fat (%)	3.03	3.47	3.60	
Milk protein (%)	3.20	3.34	3.20	
4.0% Fat-corrected milk (lb)	49.30	53.00	50.2	
Reference (11).	**% WCGF 0**	**% WCGF 20.0**	**% WCGF 30.0**	**%WCGF 40.0**
Dry matter (%)	64.90	56.30	53.00	50.40
Neutral detergent fiber (%)	30.90	39.20	42.40	45.20
Acid detergent fiber (%)	16.90	19.00	19.90	20.70
Dry matter intake (lb)	52.80	51.30	48.80	47.30
Milk yield (lb)	67.10	65.80	61.80	61.80
Milk fat (%)	2.80	2.97	3.15	3.21
Milk protein (%)	3.19	3.14	3.14	3.08
Reference (7).	**% WCGF 0**	**% WCGF 10.0**	**% WCGF 20.0**	**% WCGF 30.0**
Dry matter intake (lb)	47.20	47.20	46.30	46.30
Milk yield (%)	50.50	50.70	50.90	51.10
Milk fat (%)	3.71	3.80	3.71	3.89
Milk protein (%)	3.36	3.28	3.23	3.28
3.5% Fat corrected milk (lb)	52.20	53.10	52.70	54.50
Reference (1).	**lb WCGF 0**	**lb WCGF 5.7**	**lb WCGF 11.7**	**WCGF 17.4**
Milk yield (lb)	67.20	67.90	68.80	67.90
Milk fat (%)	3.64	3.62	3.77	3.79
Milk protein (%)	3.11	3.17	3.14	3.09
Reference (2).	**% CGF 0**	**% WCGF 27.1**	**% DCGF 27.1**	
Dry matter intake (lb)	45.90	46.30	48.70	
Milk yield (lb)	65.70	65.50	68.10	
Milk fat (%)	3.71	3.73	3.47	
Milk protein (%)	3.25	3.24	3.23	
4.0% Fat corrected milk (lb)	62.80	62.80	62.60	

Table 1. (Continued)

Reference (5).	% DCGF 21.2	% DCGF 38.5	% DCGF 57.1	
Dry matter intake (lb)	50.0	45.20	49.40	
Milk yield (lb)	59.3	58.90	58.90	
Milk fat (%)	3.6	3.50	3.10	
Milk protein (%)	3.2	3.30	3.30	
Reference (10).	**Low Fiber Concentrate**	**% DCGF 16.5**	**% DCGF 33.0**	**High Fiber Concentrate**
Dry matter intake (lb)	42.30	44.10	46.10	41.90
Milk yield (lb)	68.30	71.00	71.90	66.10
Milk fat (%)	3.20	3.20	3.30	3.20
Milk protein (%)	3.20	3.00	2.90	3.00
4.0% Fat corrected milk (lb)	58.60	61.70	61.50	59.30
% Buffer	0.00	0.00	1.00	1.00
Reference (6). % DCGF	**0**	**20.0**	**20.0**	**0**
Dry matter intake (lb)	48.50	53.60	54.00	50.30
Milk yield (lb)	67.50	74.30	75.60	71.20
Milk fat (%)	3.88	3.66	3.83	3.74
Milk protein (%)	3.32	3.35	3.31	3.36
4.0% Fat corrected milk (lb)	66.10	68.10	72.80	67.00
% Soyhulls	0.00	0.00	22.65	0.00
% Wheat midds	0.00	0.00	0.00	22.38
Reference (3).% DCGF	**0**	**22.39**	**0**	**0**
Dry matter intake (lb)	47.00	48.50	49.60	46.70
Milk yield (lb)	61.10	63.10	61.10	61.50
Milk fat (%)	3.50	3.50	3.67	3.47
Milk protein (%)	3.39	3.44	3.32	3.38
Reference (4).	**% DCGF 0**	**% WCGF 25.0**	**% DCGF 25.0**	
Dry matter intake (lb)	47.00	48.30	51.60	
Milk yield (lb)	64.40	66.10	69.90	
Milk fat (%)	3.70	3.73	3.48	
4.0% Fat corrected milk	61.30	63.10	64.20	

Table 2. Results of feeding wet corn gluten feed (WCGF) to replacement dairy heifers.

Reference (8).	WCGF ad lib	Alf. Haylage ad lib	Oatlage ad lib
Crude protein (%)	21.90	18.20	11.40
Neutral detergent fiber (%)	37.90	50.80	62.10
Acid detergent fiber (%)	14.00	41.20	44.40
Dry matter intake (lb)	18.50	18.70	13.90
Avg. daily gain (lb/d)	2.42	.95	.66
Feed:gain ratio	7.40	19.30	21.00
Reference (1).	**lb Concentrate 4.4**	**lb WCGF 4.7**	
Avg. daily gain (lb/d)	1.81	1.81	

References

1. Armentano, L. E. and M. R. Dentine. 1988. Wet corn gluten feed as a supplement for lactating dairy cattle and growing heifers. *Journal of Dairy Science* 71:990.
2. Bernard, J. K., R. C. Delost, F. J. Mueller, J. K. Miller, and W. M. Miller. 1991. Effect of wet or dry corn gluten feed on nutrient digestibility and milk yield and composition. *Journal of Dairy Science* 74:3913.
3. Bernard, J. K. and W. W. McNeill. 1991. Effect of high fiber energy supplements in nutrient digestibility and milk production of lactating cows. *Journal of Dairy Science* 74:991.
4. Delost, R. C., J. K. Miller, F. J. Mueller, N. Ramsey, J. K. Bernard, M. J. Montgomery, and C. R. Holmes. 1989. Performance of lactating cows fed wet or dry corn gluten feed. *Journal of Dairy Science* 72 (Suppl. 1):511.
5. Fellner, V. and R. L. Belyea. 1991. Maximizing gluten feed in corn silage diets for dairy cows. *Journal of Dairy Science* 74:996.
6. Firkins, J. L., M. L. Eastridge, and D. L. Palmquist. 1991. Replacement of corn silage with corn gluten feed and sodium bicarbonate for lactating dairy cows. *Journal of Dairy Science* 74:1944.
7. Gunderson, S. L., A. A. Aguilar, De. E. Johnson, and J. D. Olson. 1988. Nutritional value of wet corn gluten feed for sheep and lactating dairy cows. *Journal of Dairy Science* 71:1204.
8. Jaster, E. H., C. R. Staples, G. C. McCoy, and C. L. Davis. 1984. Evaluation of wet corn gluten feed, oatlage, sorghum-soybean silage, and alfalfa haylage for dairy heifers. *Journal of Dairy Science* 67:1976.
9. MacCleod, G. K., T. E. Droppo, D. G. Grieve, D. J. Barney, and W. Rafalowski. 1985. Feeding value of wet corn gluten feed for lactating dairy cows. *Canadian Journal of Dairy Science* 65:125.
10. Ohajuruka, O. A., and D. L. Palmquist. 1989. Response of high-producing dairy cows to high levels of dried corn gluten feed. *Animal Feed Science Technology* 24:191.
11. Staples, C. R., C. L. Davis, G. C. McCoy, and J. H. Clark. 1984. Feeding value of wet corn gluten feed for lactating dairy cows. *Journal of Dairy Science* 67:1214.

What Does the Cattle Industry Mean to Iowa?

Iowa Cattlemen's Association
Ames, Iowa

The cattle industry helps build a strong economy, creates jobs for Iowans, and results in extra income for related businesses and industries.

Direct benefits

The impact of the cattle business on Iowa's economy is no secret. The fertile fields and pastures of Iowa have long been recognized as an agricultural gold mine. Our state markets approximately 1.96 million fed cattle annually. Recent market prices in the $75-per-cwt. range translate into more than $1.6 billion worth of cattle production.

Iowa's beef industry is environmentally friendly in addition to being economically important. As ruminant animals, cattle can consume and add value to such waste materials as the by-products of ethanol production and cornstalks—the same cornstalks which, when left in the field for cattle, also reduce soil erosion and improve water quality.

Iowa's cattle industry is truly a value-added enterprise for the entire state. Cattle make use of 6% of Iowa's corn crop, adding 5.5- 7 cents per bushel, or $83 million, to the price of our corn crop. To illustrate the value-added attributes of livestock, Dr. Duane Acker has shown that in Sioux County, where farmers feed 48% of their grain to livestock, the average ag sales are $745 per acre. Contrast that to a county such as Cass, where producers feed only 15% of their grain to cattle and hogs. The average Cass County farm size is 140 acres larger, yet their per acre ag sales are only $239 per acre.

Iowa cattle also consume 3.09 million tons of hay, adding value to forage crops while keeping erodible land in soil-saving grasses and legumes.

The cattle industry is vital to Iowa's rural economy. Cattle feeding is especially important as a value-added industry that makes use of feed grains and forage crops produced in northwest Iowa. In Iowa, the beef industry is responsible for 56,054 jobs, $2.01 billion in income, and $5.22 billion in gross economic output (Otto, 1992).

Indirect benefits

Consider that the average employed person spends $7,746 on Main Street, and the average Main Street retail business has gross sales of $233,002 (Stone). To determine the amount of retail spending that is an indirect result of the cattle industry, multiply the average spending ($7,746) by the number of jobs created by the cattle industry in Iowa (56,054). The cattle industry results in $434.2 million in retail spending, enough to support 1,863 average Main Street businesses.

Of the 56,054 jobs created by the beef industry in Iowa, approximately 15,952 are directly related to the production of cattle; another 6,203 are attributable to producing feed grains for the cattle. That means that more than 33,899 additional jobs are created in the supply and service sectors.

The cattle industry also compares favorably in gross output, income and employment effects (see Table 1).

Other benefits

- Agriculture and related industries are the largest private employer in the U.S., and cattle production is the largest segment of agriculture, involving about 1.1 million family farms and ranches.
- At least 80-85% of the nutrients consumed by cattle come from sources not edible to humans—things like grass, roughage, by-products, and crop residues.
- According to Lynne W. Scott, Baylor College of Medicine, Houston, Texas: "Research confirms that lean cuts of beef, trimmed of external fat, work as well as skinless chicken and fish in low-fat diets for persons seeking to lower their blood cholesterol levels."

References

Daniel M. Otto, ISU Extension economist, "Economic Importance of Iowa's Cattle Industry," 1992 Census data.

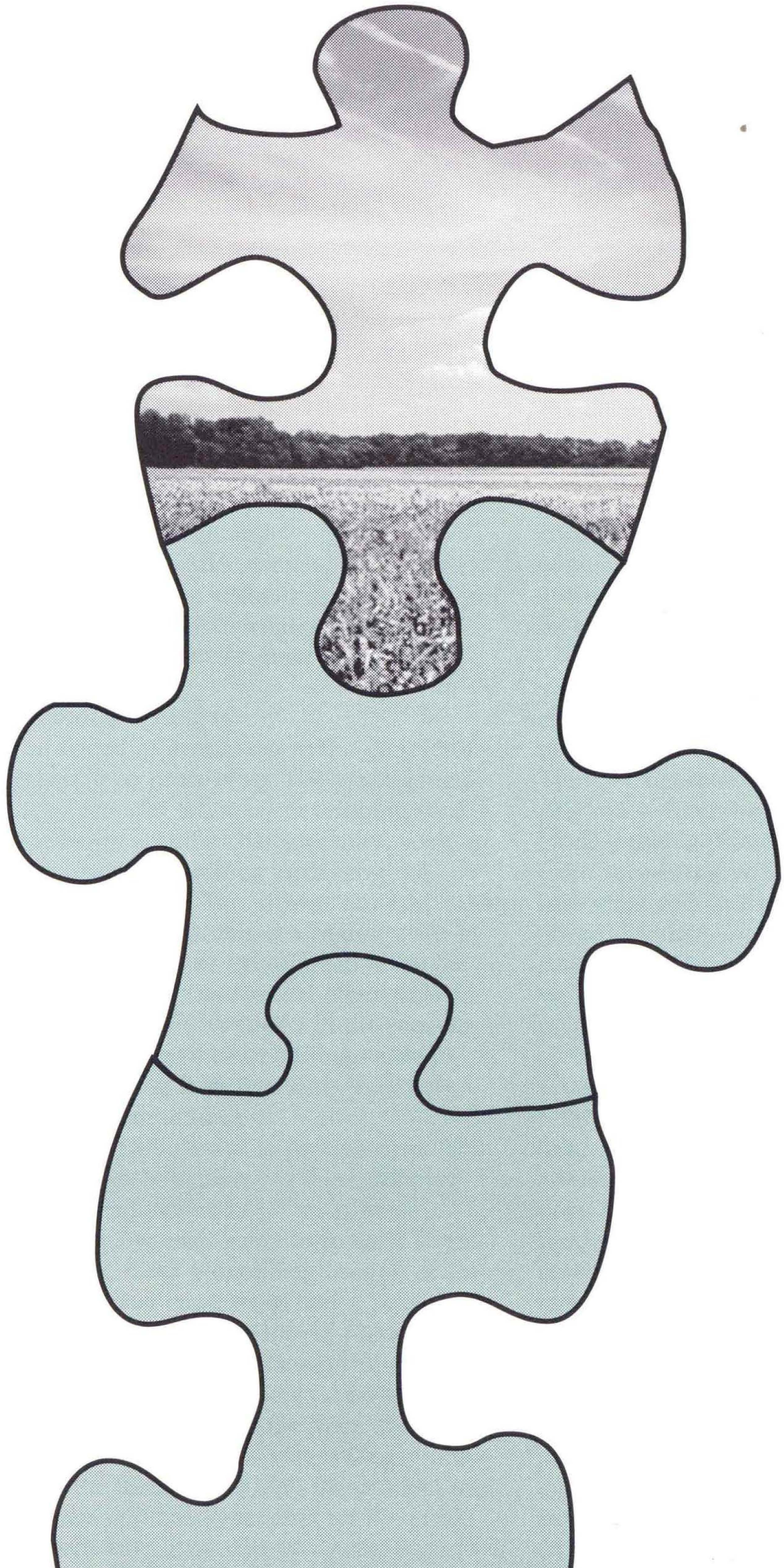
Ken Stone, ISU Extension economist.

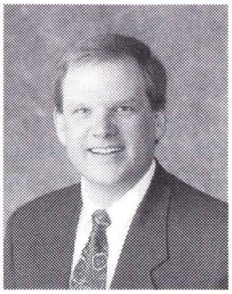
Table 1. Gross output, income and employment effects

	Gross Output	Income ($ million)	Employment
Cattle Production	1600.00	824.20	15,952.50
Other Agriculture	742.70	167.70	6,203.92
Mining/Construction	45.50	24.30	1,017.29
Manufacturing	1455.84	192.34	5,193.13
Transportation, Communication, Utilities	197.92	100.07	1,735.29
Trade	274.94	179.24	8,231.57
Financial (Insurance/Real Estate)	405.04	234.30	4,425.99
Services	455.16	262.24	12,662.52
Government-related	47.79	26.77	632.34
Total	5224.89	2011.14	56,054.54

Source: Iowa Input-Output Model, Department of Economics, Iowa State University.

New Products





Value-Added Corn Products: A Look at the Industry and Its Future

Tom Erdmann
General Manager, Cargill Corn Milling Division
Cedar Rapids, Iowa

I'm here to offer you my perspective on value-added corn products, where we've come from and where we're going. First of all, why should we pay attention to trends in the value-added corn business?

Two reasons:

1) To figure out how to make more money from corn, which is getting increasingly difficult in a more demanding, highly competitive and rapidly changeable marketplace, and
2) to meet growing consumer demand for both food and industrial products without depleting natural resources or irrevocably damaging the planet. Ethanol, of course, is one of those products.

How to add value to corn

Value can be added at every step in the cycle, from breeding to growing to processing. The plant geneticist, for example, can add value by developing seed varieties that enhance specific characteristics, such as maximizing fermentable starch or increasing the energy density of feed corn. The grower can add value by planting varieties that command a higher price in the marketplace—waxy maize versus dent corn, for instance—or by increasing operational efficiencies to reduce costs. Value also can be added in the processing. Farmers, of course, have been adding value to corn for years, by feeding it to livestock—basically, processing it through an animal.

There are many different ways to process corn. And while there will always be a place for these different methods, the processing technology that is most efficient, and extracts the most value from each kernel of corn is wet milling. Corn wet-milling uses all of the components of corn most completely, and it provides a measure of flexibility to adjust the mix of products in response to changing market conditions. The profitability of ethanol, for example, is subject to substantial market swings depending on both the price of inputs and fluctuating demand. The corn wet-milling process gives a processor the flexibility to shift the product mix more or less toward ethanol, depending on the profit picture at any given time. And that, of course, ensures a higher return-on-investment for everyone involved.

The germ, starch, gluten and fiber are all separate initially and then each of these components goes on for further processing into a variety of products. The germ is processed into various grades of oil, as well as into feed. Gluten and fiber are processed into various feed products, including corn gluten meal and dry and wet corn gluten feed.

For more than 100 years, our industry has focused on extracting as much starch as possible from each kernel. The starch molecule is the building block for the majority of the products we make today, and will provide the foundation for most of the new products we will develop in the future. For decades, we concentrated primarily on manufacturing lightly modified corn starches and simple glucose syrups. In the 1970s, we learned how to make high-fructose corn syrup. The 1980s brought ethanol. And the 1990s is turning out to be the decade of bio-products.

New technologies commercialized in the last several years, however, make possible the manufacture of chemical products from corn-derived feedstocks, rather than their traditional petrochemical sources. Things like amino acids, vitamins, food stabilizers, pesticides, flavoring agents, adhesives, pigments, and biodegradable plastics can now be made from corn. Corn processing will play a large and increasingly important role in the Iowa economy in the years ahead. Markets for traditional corn products will continue to strengthen and to grow. Plus, I believe we'll see exciting development in a number of new-product areas. Let's take a closer look.

Current products

There is clearly a bright future for our most basic food ingredients. Food-grade starches, syrups, and oils are found in thousands of products, with new applications being made each day. World demand for these products will continue to grow well into the next century. This demand will be fueled by several global mega-trends, such as overall population growth.

Population growth

According to the most likely scenario, by the year 2025 the world population will increase more than 50 percent from roughly 5.5 billion today to 8.5 billion only 30 years from now. The world demand for food over that same time period is predicted to increase 100 percent—twice the rate of population growth—because global standards of living are rising along with the population. As standards of living rise, people demand greater value and convenience, which means more prepared, ready-to-eat, instant, no-cook, and microwaveable products, many of which use corn starches, syrups, and oils.

Another global trend that will sustain growth of the food-grade segment of the corn industry is the increase in per-capita consumption of grain-based foods—up 20 percent since the mid-1980s—as well as no-cholesterol oils. This, of course, is the result of consumers' increasing health consciousness, their desire for variety, and also rising consumption of traditionally ethnic foods.

A second current corn product that also will continue to enjoy healthy growth in the years ahead is high-fructose corn syrup. Again, this growth will be fueled by compelling marketplace trends. One of these is the consumer trend toward nutritive—and away from the diet—soft drinks. This is related to increasing health consciousness and concern about the safety of artificial sweeteners. Perhaps even more significant for the growth of fructose, particularly in the long run, is the fact that trade barriers are falling around the world. This is opening up new geographic markets for the product, and also changing the fundamental drivers of sweetener production and consumption.

One big market is Mexico. It's a complicated equation but, in much simplified terms, when you factor in population growth, demographics, infrastructure, water quality, and changing government sugar subsidies, the growth potential for soft drinks manufactured using fructose in Mexico is absolutely huge. Add NAFTA to the equation—which stipulates that duties on imports will be reduced to zero over a 10-year period—and the economies shift very much in favor of manufacturers who make fructose right "in the cornfield" and then ship it to bottlers in Mexico.

Iowa is unparalleled in terms of the number of cornfields and corn-processing facilities. There are and will continue to be similar opportunities for us around the world as major bottlers such as Coke and Pepsi expand globally at exponential rates.

Industrial corn starch is a third current product area that will play a major role in the health and growth of the corn industry in the years ahead. We need look no further than the paper industry for several examples that confirm an optimistic outlook. The underlying mega-trend is environmentalism.

Environmentalism

Use of recycled fibers in the paper and boxboard industry will continue to grow and so will demand for specialty grades of corn starch. Fibers in recycled paper are shorter than virgin pulp, and need binders to give the product strength. Corn starch provides those binders.

There is another industry trend also driven by environmental concerns away from acid and toward alkaline paper processing. This trend is causing a shift in both the absolute amount and the type of starch that is needed. Highly modified dent- and waxy maize-based starches are used to bind the effluent in alkaline processing so it doesn't wash out with the wastewater and pollute the environment.

These factors—coupled with steadily increasing demand for printing and writing papers that keep the laser printers, copiers, and fax machines of this county humming—present an exciting growth picture for highly modified starches in the years ahead.

Ethanol products

Ethanol also has a bright future for corn growers and processors. Although ethanol has been around for decades, it is driven by the environmental mega-trend. We're still debating it. Despite opposition from the oil industry that will make demand a bit unpredictable in the short-term, in the long run, ethanol will survive and flourish because ethanol makes sense.

In terms of the environment, ethanol is a very clean-burning fuel, helping us meet the air-quality standards for urban air.

As a renewable fuel, ethanol is part of the natural carbon cycle. It helps reduce the growing problem of greenhouse gases be converting solar energy into motor fuel that doesn't deplete our finite resources of fossil fuels.

Ethanol is also a domestic fuel. It reduces our dependence on foreign oil and expands the market for U.S. agricultural commodities. In the short term, the profitability of ethanol will continue to be subject to substantial swings, both in the cost of inputs and in market demand. The best way to ensure a profitable return on this particular investment—at least in the short term—is to have a flexible process, the kind of flexibility that is built into corn wet-milling.

Feed products

The production of corn-based feed also provides a bright future for corn processors. From the perspective of a corn processor, my perception is that our industry is increasingly recognizing the importance of developing domestic markets for our gluten-meal and gluten-feed products. There are two trends encouraging us to move in this direction.

First is less restrictive trade around the world. The result is that countries that have traditionally been major consumers of gluten feed will move more toward whole grain and other feed ingredients. This allows more gluten feed into the domestic market. Secondly, as overall production of corn-based products increases, there will simply be more gluten produced.

Together, these two trends will present very attractive opportunities for domestic feeders, the most attractive ones being for feeders who are convenient to corn mills where they can feed the product wet. Our new plant in Blair, Neb., for instance, will sell only wet gluten feed to supply local market needs. It's an arrangement that offers real benefits in both cost and efficiencies for everyone involved.

Working together

By working together, we can all gain. Our success is your success, and yours is ours. Remember, this is the value decade. As Jack Welch said, "If you can't sell a top-quality product at the world's lowest price, you're going to be out of the game."

Let's face it; each of us has a very specialized role in extracting value from corn. By focusing on what we each know best, we get increasingly efficient at our particular link in the value chain. So when we put all those highly specialized and efficient links together, we create a chain that has far greater strength than any of us could make on our own. That's the essence of why we need to work together, as partners, because when one of us wins, we all win.

There's a business training exercise that shows the increasing importance of this type of cooperation as the world gets smaller and more complex. The way it goes is, you draw an imaginary line on the floor, and put one person on each side. The objective is to get one person to convince the other, without force, to cross the line. It's an interesting exercise.

And it turns out that U.S. players almost never convince one another, but their Japanese counterparts simply say, "If you cross the line, so will I." They exchange places and they both win.

That's the kind of approach we need to take as we face the future together if we are to realize the full potential of this vibrant, dynamic industry!

Future products

I don't claim to have a crystal ball, but I think it's safe to say we will see major developments in three key areas: Bio-tech products, food and feed, and industrial applications.

Biotech products

This will be the leading source of expansion for our industry in the years ahead. Experts generally peg the numbers at 30-40 percent over the next few years. Right now, we're making chemicals, such as citric acid and MSG, from a dextrose feedstock. But we've only just begun to tap the potential of this new fermentation technology. Who knows what tomorrow may bring?

One possibility is making ethanol from corn fiber, rather than from starch-based dextrose. This would require the development of new yeasts and fermentation technologies, since current yeasts used in fermenting starch-based sugars don't work on fiber-based sugars.

The Corn Refiners Association and the National Corn Growers Association recently offered funding for two research projects to develop those new yeast strains, so who knows how far away—or how close—we are to having this new technology?

What we do know for sure, however, is that we'll see dramatic growth in the entire area of making organic chemicals from corn-based feedstocks through fermentation. That's being driven by economic as well as environmental factors, which are often interrelated.

First of all, corn is a renewable material; oil, coal, and natural gas are not. Corn is a domestic source, not an insignificant factor in these days of economic uncertainty and politically-charged debates over balance-of-trade issues. In terms of cost, it generally costs less to construct a biochemical production facility than it does a petrochemical one.

Operating costs of a biochemical production facility are also lower than a petrochemical facility. Much less equipment is needed, and the biotech process incurs significantly less safety risk to employees and the environment, which that has major economic benefits.

For instance, handling and processing dextrose is less expensive than working with benzene, that as an EPA-regulated toxic waste and air-pollutant, requires numerous safety and environmental-protection procedures. In terms of by-products and waste, virtually all by-products from biochemical production can be used as feed or fertilizer, while many of the by-products and practically all of the waste from petrochemical production is harmful to humans, animals, and the environment.

The efficiencies we can realize today in the transportation of finished goods gives Midwestern producers an advantage over other producers. For instance, even though Asian and European scientists developed some of the fermentation technologies we are now using, their cost of raw materials is much higher in those countries than in the United States.

Food and feed

New food and feed applications is another area in which will see significant growth in the years and decades ahead. For instance, major food companies today direct substantial efforts to developing and bringing to market foods that are low-fat, low-cholesterol, high-protein, and even therapeutic. As our customers, those companies look to us to provide them specialty food ingredients for their more healthy, re-engineered food products. It's likely that we may make some of these products, including fat and meat substitutes, from corn through fermentation.

In the feed area, we have a tremendous opportunity for improving efficiency within our industry. Now that we can make amino acids and vitamins from corn, we add them to feed products right at the plant. This adds value for the producer, increases demand for the grower, and lowers cost to feeders. It's another example of the win-win situations that we can create for ourselves by working together as an industry.

Industrial applications

And the third area where we have major opportunities in the years ahead is industrial applications. With a few notable exceptions, these are product and market segments that have been largely untouched by our industry to date, but their potential is enormous. A Department of Energy study last year concluded that 19 of the 50 most widely used chemicals in the United States could wholly or partly be replaced by ones produced using biomass feedstocks.

One such application that is getting a lot of attention today is a true, biodegradable plastic. This is a market with huge potential: 16 billion pounds of disposable plastic are consumed every year in the United States alone. Most of you have probably heard of EcoPLA™, Cargill's entry into this new arena. I am certain that this product segment will be an exciting growth for our entire industry in the future, for obvious environmental reasons.

Bio-pesticides are another industrial application that has lots of potential for our industry, and again, environmental concern is the driving force. Pesticides are a $25 billion retail market on a global basis. Currently, almost all pesticides are petroleum-based. The EPA is considering banning or restricting the use of many of those products. Corn could provide the ingredients for environmentally safe, natural pesticides. At the moment, this market is virtually untapped by our industry.

Together with the strong growth prospects I've already outlined for our current products, the future of the Iowa corn industry seems quite bright indeed. Even so, we must not lose sight of the fact that such a future is by no means a given. We still have to work to make it happen.

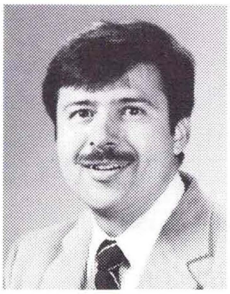
Conclusions

So what do we need to "put in" to achieve the bright and expansive vision of the future that I've outlined? First, we need to share the vision. We need to share the dream. The dream is what gives us direction, and keeps us on the right track. Perhaps even more importantly, the dream gives us inspiration. It keeps us moving ahead, even in the face of inevitable setbacks.

Secondly, we need to work together as an industry. The players in the corn value-chain have a symbiotic relationship; in other words, our individual failures or success are shared across the entire system. Remember the story of the training exercise I told you about earlier? Failure or success was a mutual proposition. When one partner won, they both did. That type of cooperation will become increasingly more important as the world gets smaller and more complex and more competitive.

Third, at each step of the process, our goal must be to continually improve and develop our unique core competencies. It's a truism in business today that, in order to stay successful, all enterprises—from family farms up to global corporations— must go through periods of evaluation and self-renewal. This process is more evolutionary than revolutionary, making each of us more effective in delivering our piece of the puzzle. By concentrating, focusing, and continually improving upon our own area of expertise, each of us will be able to contribute a better, stronger, more efficient link to the value chain.

When we put those links together, there is a cumulative, synergistic effect. The chain is stronger for all of us. As a result, as an industry we will be able to offer consumers the highest value in the world. At the same time, we will be able to take pride in delivering solutions to our most pressing global problems, from environmental threats to the increasing demand for more and healthier foods.



The Dynamic Duo: Corn and Microbial Fermentation Plants

Anthony L. Pometto III
Center for Crops Utilization Research , Iowa State University
Ames, Iowa

Microbial fermentation is one of the fastest-growing areas of industrial corn utilization. The continuous liquefaction of corn starch to glucose corn-syrup for the high-fructose sweetener market has sparked this expansion. In the beginning, the glucose stream that was not acceptable for sweetener production was used for ethanol production. Today, the sweetener side-stream and the main starch-liquefaction stream both are being used for the production of amino acids, organic acids, organic alcohols, vitamins, enzymes, antibiotics, single-celled-protein, genetically engineered products, and more.

Growth in this industry, particularly in the Midwest, is extremely rapid. Commercial fermentation facilities have four main requirements: a trainable work force; an inexpensive, reliable energy source; a clean, reliable water supply; and an inexpensive, reliable carbon source. All of these components are found in the Midwest; carbon especially is accessible through our abundant supply of corn.

Corn is the ideal carbon source for many reasons: (1) properly dried corn can be stored for years, providing a plentiful year-round carbon source; (2) the corn industry interfaces with hundreds of food and non-food industries, making the marketing of high-valued products almost effortless; (3) microbial fermentation is a natural process and, therefore, environmentally compatible; and (4) with computer controls, safety concerns associated with large-scale fermentation plants have diminished.

Liquefied corn starch has become the preferred starting material for many microbial fermentation plants. It costs less than crystalline dextrose. The corn-syrup stream can be customized to produce mono-, di-, tri- or oligo-saccharides depending on specific fermentation requirements. For example, a common corn syrup blend used by the pharmaceutical industry contains dextrose (19%), maltose (14%), maltotriose (12%), and higher saccharides (55%). Many fermentation facilities are located adjacent to corn wet-milling plants with starch-liquefaction capabilities. Corn syrup can be piped directly into the fermenter on an as-needed basis. In some cases, it is transported by truck or rail to the facility.

Advances in product recovery also have benefited microbial fermentation plants. Membrane filtration processes continue to improve and are used routinely in cell mass and/or product recovery. Advances in product recovery by using solid-liquid or liquid-liquid extraction constantly are being developed for many highly valued products such as organic acid, amino acids, and vitamins. Distillation is used routinely for the recovery of volatile products like ethanol.

Microbial fermentation generates two new co-products from corn: (1) cell mass, and (2) spent culture medium. The biomass produced (bacteria, fungi, or yeasts) often is a highly valued product used as a nutritional enhancer in animal feed. The spent culture medium (liquid waste stream) can be used in animal feed if the plant is close to a livestock facility, or it sometimes can be applied directly to the land as a fertilizer. It also can become a waste disposal problem, however, that requires some type of bio-remediation. Some waste may be used for biogas production, which can reduce the plant's energy expenditures.

Today, ethanol production is the major consumer of liquefied corn starch, with consumption projected at 930 million bushels of corn per year by 2000. As new product markets develop and new fermentation facilities are constructed, however, ethanol fermentation plants could face some competition. The most immediate will be lactic acid fermentation plants for the production of the degradable plastic polylactic acid. Initially, polylactic acid production is projected to utilize at least 300 million bushels of corn per year, which is the level at which the ethanol fermentation industry began in 1986. As polylactic acid production costs begin to decrease from the current $5 per pound, however, even more uses for this unique polymer will be identified around the world, resulting in even greater corn consumption.

The sky is the limit. From the liquefied corn starch stream, microbial fermentation plants are capable of producing commodity chemicals for liquid fuels or degradable plastics, as well as highly valued products. The combination of corn and microbial fermentation plants is an unbeatable team that will have a major impact on corn consumption and the world far into the next century.

Rural Economic Value-Added Mentoring Program (REVAMP)

The Iowa Department of Agriculture and Land Stewardship (IDALS) through the Office of Renewable Fuels and Co-Products has established the Rural Economic Value-Added Mentoring Program (REVAMP). The program is designed to provide business planning assistance to people who want to develop value-added industries in Iowa.

The goal of REVAMP is to revitalize the economy of rural Iowa by fostering the growth of businesses that will increase demand for raw agricultural commodities. The ultimate intent is to create income, jobs, and opportunities for Iowans through processing of value-added products and developing new uses for Iowa's agricultural commodities.

Developing value-adding companies often requires intensive management and significant capital investment. Through REVAMP, the IDALS assists individuals and organizations in developing a sound business plan and obtaining the detailed financial analysis necessary for acquiring capital.

Mentors assist with planning

REVAMP provides mentors (qualified consultants) to help clients develop ideas into workable solutions. Mentors play a crucial role in the program—providing advice on everything from setting business goals to marketing, production, and finance. Mentors will be recruited for each client's particular needs.

REVAMP offers participants the following types of assistance.

Defining business goals and objectives. Planning any business development project, whether start-up or expansion, begins with establishing goals and objectives. This is the process of defining what the business should be at the point of inception, in five years, and into the future. REVAMP mentors can help turn ideas and goals into reality by matching an organization's capacity with production and marketing potential. With a defined set of business goals, program staff will assist clients in identifying specific strategies to attain their objectives.

Developing a business structure. The first step in creating a business is selecting the most advantageous business structure. This selection will affect profitability, liability, and management control. The proper business structure must be accompanied by a well-planned and efficient management system. REVAMP mentors can assist in this process by:

- explaining the advantages and disadvantages of proprietorships, partnerships, cooperatives, and corporations;
- contacting legal experts to aid in selection and formalization of the most suitable business structure for each facility;
- defining management goals that conform to the structure and facility's owners
- developing a management structure that specifically identifies the responsibilities of management;
- identifying logical management divisions within the proposed operating structure; and
- devising a compensation plan that provides management and operating personnel with clearly defined performance incentives.

Identifying market opportunities. Successful marketing begins with the identification of market opportunities. The selection of specific markets to enter will be determined by market constraints and each client's competitive advantages. REVAMP mentors can assist with the analysis and identification of market advantage, and the selection of target markets by helping clients:

- develop a marketing plan;
- evaluate the capabilities of each client's facilities and product;
- define the market segments and geographic areas in which it is economically viable to market each product;
- identify market potential;
- identify product requirements for servicing targeted markets;
- evaluate expected trends and pricing strategies
- establish distribution strategies; and
- define marketing communications strategies.

Analyzing facility costs. Estimating and evaluating expected costs of production are dependent on the quality and amount of raw product available to the facility to process and market. The identification of operation costs also will influence each company's ability to raise equity capital. REVAMP can assist by:

- identifying a supply of product for the operation
- evaluating and advising on the suitability of sites and available equipment;
- comparing the costs and benefits of possible options in equipment and site selection;
- researching available equipment types and resources;
- outlining depreciation requirements and the expected timetable for equipment replacement;
- locating technical expertise for facility layout;
- soliciting plans and estimates for new construction

or for adapting existing structures;
- outlining staffing requirements and estimating personnel costs;
- evaluating minimum efficiency and maximum capacity of the facility;
- evaluating the facility's capacity to handle more than one product;
- determining shipping and handling requirements;
- identifying the required transportation and storage conditions, and
- projecting cash-flow needs, equity/capital position and profit/loss statements for the initial five years of the proposal.

Securing capital. Financial planning requires continuous attention throughout all stages of the process. An estimate of the potential client equity contribution is an important basic step toward defining facility size and equipment needs. Obtaining debt capital often depends on the particular market targeted and the facility options pursued. Given the client's anticipated equity contribution, REVAMP mentors can assist in:
- identifying short and long-term cash-flow needs;
- comparing short-term cash-flow needs with earnings;
- comparing long-term cash-flow needs with equity investment;
- determining the need for outside investment or loans;
- estimating loan values of real estate and equipment
- estimating the level of debt that equity will support
- determining the facility's ability to obtain long-term credit;
- identifying sources, conditions, and terms of development assistance available from private and public sources;
- determining the requirements of all potential lenders and creditors;
- outlining the order in which financial sources are expected to commit funds;
- developing a comprehensive financing package that meets the needs of the facility,
- assisting in negotiating terms for loans and outside investments.

REVAMP program guidelines

Very simply, the program provides and pays for technical assistance (mentoring) and provides financial assistance to help transform a business idea into a sound business plan—and then into reality. Here are the steps in the process:

1) Interested individuals or Iowa companies file a Planning and Technical Assistance Application and Memorandum of Understanding with the IDALS Office of Renewable Fuels and Co-Products.
2) The IDALS then pays mentors (qualified consultants) up to $1,000 to review the initial project plan and make recommendations on the project's viability.
3) Based on the consultant's recommendations, the IDALS may provide up to an additional $24,000 in financial assistance for mentoring to complete a business plan which will include the following:
   Potential of the business
   Project budget and status of alternative financing
   Management structure
   Personnel needs
   Description of product process or practice
   Production operations
   Status of product or service development
   Marketing plan for the project
   Patent status, if applicable

   There is no time limit for the technical assistance required to complete the plan.
4) Once the business plan is completed, the applicant may apply for VAAPFAP (the Value-Added Agricultural Products and Processes Financial Assistance Program). VAAPFAP, administered by the Iowa Department of Economic Development, is making $53.65 million available for assistance to new or existing value-added production facilities.

REVAMP eligibility requirements

An applicant must be interested in developing a value-added industry located in Iowa by:

1) Producing a product from an agricultural commodity which was not previously produced from that commodity; or
2) Developing a new process for producing a product from an agricultural commodity which was not previously used to produce that product; or
3) Establishing or expanding a renewable fuel production facility.

The applicant must submit a Planning and Technical Assistance Application, and sign a Memorandum of Understanding with the Iowa Department of Agriculture and Land Stewardship.

For further information on REVAMP, contact the Iowa Department of Agriculture and Land Stewardship, Office of Renewable Fuels and Co-Products, Henry A. Wallace Building, Des Moines, Iowa 50319, Tel: (515) 281-6936, FAX: (515) 281-6236.

The Alternative Agricultural Research and Commercialization (AARC) Center

The Alternative Agricultural Research and Commercialization (AARC) Center is a U.S. Department of Agriculture agency created by Congress in 1990 as part of the farm bill (P.L. 101-624 Title XVI, Subtitle G) to expedite development and market penetration of industrial (non-food, non-feed) products from agricultural and forestry materials. It assists the private sector in bridging the gap between research results and commercialization of that research, thereby complementing USDA's research agencies. Preference is given to projects that benefit rural communities and are environmentally friendly.

The Center is an independent entity within the U.S. Department of Agriculture, headquartered in Washington, D.C. For organizational purposes, the agency reports to the Under Secretary for Rural Economic and Community Development.

Following are answers to questions commonly asked about the AARC Center:

How does the AARC Center differ from other USDA agencies?

It does not duplicate existing programs and is not a research agency, rather, it is dedicated to commercialization. USDA research agencies may share research results or provide technical assistance to the private sector. As a public entity, the AARC Center forms partnerships with private firms to commercialize research which may have been developed with public or private funds.

How is it governed?

Policy and program direction is provided by a nine-person board of directors—eight of whom are non-federal—representing processing, financial, producer, and scientific interests.

How is the AARC Center funded?

The Center receives an annual appropriation from Congress; it also operates a revolving fund. That is, when the Center begins to receive repayments, the money will be invested in other projects.

In its first two years of full operation, how many projects has the AARC Center funded?

For fiscal years 1993-94, the first two years of full operation, the AARC Center invested $15.3 million, matched by $43 million from private partners, in 39 projects to promote new, innovative, and environmentally friendly uses for farm and forestry materials. The AARC Center requires at least a 50% match for these pre-commercial activities from the private sector partner and negotiates a payback arrangement for each project. The private-public ratio is approaching three to one, however; some projects involve a royalty arrangement, while others involve stock options, i.e. equity in the firm.

Is there a limit on the size and number of investments?

The number and size of awards currently are limited only by the amount of money available in the fund at any given time. Investments generally range from less than $100,000 to $1 million.

What criteria are used to determine whether or not the AARC Center will support a project?

Applicants must demonstrate management, technical, marketing, and financial expertise. Other areas considered include: the availability of matching funds, economic viability, private financial participation, potential market size, potential for jobs creation, rural development, state or local government participation, likelihood of reducing federal commodity support over time by using a "program crop," likely impact on resource conservation, likely impact on the environment, lack of private capital, broad applicability, biodiversity, viability without continued assistance, and eventual ability to repay the AARC Center.

Who may apply for AARC Center support?

Any private individual or company may apply for assistance. Most of the Center's clients are small firms and non-profit corporations or cooperatives. Universities and similar institutions may participate, but their private business partner generally leads in commercialization activities.

How does the AARC Center help businesses?

The AARC Center can supply financial assistance at the pre-commercialization stage of a product—that point in a business at which costs often are greatest and ability to obtain funding from traditional business sources is least. At the pre-commercialization stage, a product is expected to have an identified market. Additional work may remain, however, before the product enters the marketplace—e.g., prototype testing or manufacturing runs, regulatory clearance, or market analysis.

Is the AARC Center financial support a loan?

No. The AARC Center makes repayable equity risk investments such as buying redeemable stock or taking a percentage of future sales. The investment is usually a repayable cooperative agreement. Applicants are expected match AARC funds one-to-one.

How are projects selected for AARC Center support?

Applications undergo evaluation by three outside reviewers and the AARC Center staff. Reviewed are: the technical feasibility of the proposal, the project's potential to generate jobs in rural communities, and any effect the project may have on the environment. After a successful review, an application is referred to the AARC Center's board of directors for final evaluation. Board members and staff make site visits to exercise "due diligence" and sometimes require oral presentations on the overall proposal.

Is the information on projects submitted for funding kept confidential?

Proprietary information is protected throughout the review and evaluation process, and procedures are in place to avoid conflicts of interest. The legislation establishing the AARC Center specifically exempts the Center from the provisions of the Freedom of Information Act, offering further privacy protection to applicants.

When may applications be submitted?

Applications may be submitted at any time. At least two review sessions are held each year, with successful applicants announced approximately three months after the start of the review. Applicants may submit a pre-proposal or a full proposal.

Who will own the rights to the intellectual property?

Title to any intellectual property developed under a joint agreement with the AARC Center will remain with the applicant. While federal legislation requires so-called "march in" rights for the government with regard to any invention supported with federal funds, the private sector firm would be compensated through a licensing/royalty arrangement in the unlikely event that such rights were exercised.

What types of projects were funded in 1993-94?

- *Corn.* Windshield washer solvent, starch-encapsulated pesticides, polyols.
- *Crop residue, grass and waste newspaper.* Biomass conversion to ethanol and other chemicals.
- *New crops.* (Kenaf) "spaceboard" panels, mats for grass seeds, paper; (lesquerella) specialty lubricants and cosmetics; (crambe, rapeseed) lubricants which biodegrade in marine or forest environment; (hesperaloe) non-polluting paper source; (milkweed) floss—for use in hypoallergenic pillows and comforters; (castor)—for use in lubricants, paints and cosmetics.
- *Soybeans.* "Environ" composite wood replacement from waste newspaper and soybean meal, soy diesel.
- *Wool.* Using lower-grade wool to absorb oil spills.
- *Cotton seed lint.* An oil-absorbent which biodegrades hydrocarbons.
- *Composted agricultural and forestry wastes.* Create potting soil with biocontrol agents for pathogens.
- *Wheat straw.* Walls for housing, fiberboard, highway sign posts when mixed with recycled plastic.
- *Peanut hulls.* Cat litter and carrier for crop protection materials.

By law, the agency is prohibited from using more than 25% of available funds for projects involving animal by-products (Sec. 1660 (d)(2).)

The idea of new uses for agricultural products has been around since the 1930s, especially when commodity surpluses were high. Why are the federal government and private industry now making a consistent commitment to commercialize new products?

What's different? Increased concern for our environment: We now recognize that all kinds of pollution—acid rain, ground water contamination, air pollution—are linked to hydrocarbons and petrochemical products, including fuels. In general, farm-grown raw materials pose fewer environmental costs, especially when the crops are grown using sustainable agricultural practices.

National security concerns. Why should we rely on distant, sometimes unfriendly, countries to meet our energy needs?

Economics. Why import raw materials when we can produce them at home and strengthen our local and regional economies at the same time?

The petroleum industry peaked in the 1970s. Now, we are aware of the advantage of relying on renewable resources rather than finite ones for industrial raw materials.

Why would new uses for agricultural materials be more competitive today than in the 1930s?

- More efficient technologies have been developed for processing and manufacturing agricultural materials—e.g., biotechnology, continuous fermentation ,and advances in catalytic processes.
- Environmental regulations have driven up the cost of disposing of the co-products of manufacturing and packaging. "Biodegradable" is now a household word.
- The availability of skilled labor and resources in rural America.
- Increased pressure to reduce agricultural subsidies.

How do I get an application?

Write or fax a message to the Alternative Agricultural Research and Commercialization (AARC) Center, U.S. Department of Agriculture, 0156 South Building, 14th and Independence Avenue SW, Washington, DC 20250-0400, Phone: (202) 690-1633, Fax: (202) 690-1655. The director is Bruce Crain.

Contacts

To get a copy of this book, contact the ISU Extension Distribution Center at 119 Printing and Publications Building, Ames, IA 50011, or call (515) 294-5247. Copies of the 15-minute video produced for this project, "Corn: Adding Value to Iowa's Future," can be checked out from any county or area extension office.

To contact sponsoring groups, use the following addresses:

Agribusiness Association of Iowa
900 Des Moines Street
Des Moines, IA 50309
(515) 262-8323

Farm Credit Services
1200 35th Street - 302 West Towers
West Des Moines, IA 50266
(515) 222-0884

Iowa Cattlemen's Association
123 Airport Road-Box 1730
Ames, IA 50010
(515) 233-3270

Iowa Corn Growers Association
1200 35th Street-306 West Towers
West Des Moines, IA 50266
(515) 225-9242

Iowa Department of Agriculture and Land Stewardship
East 9th and Grand
Des Moines, IA 50319
(515) 281-6936

Iowa Department of Economic Development
200 E. Grand Avenue
Des Moines, IA 50309
(515) 242-4801

Iowa Institute for Cooperatives
2515 Elwood Drive
Ames, IA 50010
(515) 292-2667

Iowa State University Extension to Business and Industry
104 EES Building-Haber Road
Iowa State University
Ames, IA 50011
(515) 294-0648

Iowa Soybean Association
1025 Ashworth Road #310
West Des Moines, IA 50265
(515) 223-1423

Many thanks to those who provided us with copies of their conference remarks, overheads and technical papers for use in this book; also to Elaine Edwards, Annette Adcock and Laura Miller, extension editors who compiled and went through the material; and to Valerie King, for design and layout.

Files: Animal Science 4, Agronomy 2-2, and Communities 3-1

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Robert M. Anderson, Jr., director, Cooperative Extension Service, Iowa State University of Science and Technology, Ames, Iowa.