NON-TRADITIONAL PRODUCTS FROM CORN

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The productivity of our farm sector is one of the great success stories of history. The application of genetics, fertilizers, herbicides, pesticides, irrigation, and new cultivation practices has provided us with an ever increasing yield. Of course, we must acknowledge the tremendous contribution to this type of agricultural productivity which has come from the land grant universities and their ability to sell their improvements to the actual producers. Thanks to the application of these technologies, the crop has become much more dependable, and the swings between the fat and lean years diminished.

That such capital intensive industries as the corn refiners can justify expansion and research into new products is a reflection of our confidence in the continued improvement in crop productivity. The price of corn in both absolute terms and relative stability is of critical importance to us. The price trend for corn over the recent decade actually declined in terms of constant dollars.

This does not mean, however, that we have been immune from fluctuations in the cost of our raw material. In the corn wet milling industry, we emphasize the products from carbohydrate or starch which represent about two-thirds of the weight of the corn kernel. The non-starch materials are oil, fiber, and protein, which are sold as commodities. Therefore, when we approach the economics of starch-derived products, we utilize by-product accounting. That is, we cost the starch portion at the cost of corn less the value of the commodity co-products.

The variance in starch dry substance shows costs after recovery of standard yields of gluten feeds and oil over the past several years, and demonstrates that there is still a very significant, and unpredictable, variance in the cost of our raw material, that is wider than the corn price. This variation, and our inability to control it, heavily influences our ability to expand into competition with commodities such as sugar and gasoline. The key variable is the corn gluten feed value whose price moves independently of the price of corn. Further, since $3 corn is equivalent to $115 per ton feed, you can see that the unit value of this co-product is roughly the same as corn.

If corn-derived products are to grow into non-traditional markets, or at least into markets which at some time in their history have been lost to petroleum-based products, we must be able to show an economic advantage for the corn-based raw material. When the starch fermentation medium was at the 30 cents to 40 cents per gallon level two years ago, announcements of new alcohol fermentation capacity appeared at the rate of two or three every week. Now that there is a realization that fermentation media costs can also vary, there have been numerous deferments and cancellations in these plans.

Thus, in spite of the tremendous improvement in basic agricultural productivity, a substantial degree of raw material price uncertainty still clouds the future of additional new products from grains. A major variable is the co-product recovery. In our case, the rapid growth of the European Community market for corn gluten feed and corn oil have absorbed corn wet mill growth.

This tonnage has grown over the past 10 years and we project possible future growth from announced industry expansions for high fructose, the potential for 350 million gallons of ethanol from wet millers, and the potential incremental amount from another 350 million gallons per year of ethanol by the mash process which yields DDGS. The current 2.5 to 3.0 million tons of gluten feed which is absorbed by the EC has pretty well saturated this market, and there have been numerous discussions by members of the EC about restricting further growth.

Whether this resistance is directed at DDGS from subsidized alcohol production, or is broadened to restrict all U.S. produced corn derivative feeds, remains to be seen. In any event it is important that the wet corn milling and grain alcohol industries not expand more rapidly than their ability to market their co-products. The encouragement of disorderly expansion through federal government loan guarantees, and even grants for capital investment in additional capacity, could well hasten the day when countermeasures are introduced within the EC.

The second phase of agricultural productivity deals with industry's contribution towards the conversion of raw grains to higher value products. The cost of starch in corn at $3.50 per bushel is about 7½ ¢ lb. Some specific opportunities for the application of starch conversion chemistry to add value are:

Refined sugar, now at 15¢ — 20¢ lb; Ethanol, 27¢ lb; Citric acid, 70¢ lb; Sorbitol, 46¢ lb; Detergent alkylates, 46¢ lb; Acetic acid, 26¢ lb.

The greatest success story of the corn industry is the recent penetration of the sugar market with high fructose corn syrup. This is a "non-traditional" product in that in the previous 80-year history of the industry, we did not have a product chemically and functionally equivalent to sugar.

The industry had seemed to mature in the late 1960s because corn syrup, dextrose, and starch markets had levelled off, and industry growth was basically reflecting the GNP. In 1970 a technological breakthrough occurred giving us the capability to produce a product nearly equivalent to invert sugar. The growth rate for this product is high and high fructose corn syrup now has 30 percent of the U.S. sweetner market.

The commercial 1980 production was about 5.7 billion pounds, utilizing 121 million bushels of corn, or over 25 percent of the industry's corn consumption. The high fructose industry is expected to reach approximately 9 billion pounds by 1985. This success story reflects two technological breakthroughs: The commercialization of isomerase to convert dextrose to fructose, and the liquid chromatographic separation for fractionation and enrichment of higher fructose products. These processes are now cost effective.

The growth history and projection for future growth leads us to a point in the late 1980s where domestic production of high fructose corn syrup and sugar could satisfy the total U.S. sweetener requirements without imports. As we approach this point, we may begin to see the impact of the disappearance of the only hard dollar market for world sugar.

Other "non-traditional" markets are those where we replace other raw materials such as petroleum. The most likely such market at this time is ethyl alcohol. At the present, corn is a lower cost raw material for industrial alcohol than ethylene and, with the anticipation of decontrol of natural gas, this advantage may widen further. The potential for this market is 200 — 250 million gallons per year, which would consume about 100 million bushels of corn. The use of alcohol as an extender in motor fuel is not yet competitive with $1 per gallon gasoline. However, as an octane enhancer at the 10 percent level, it competes with aromatics, now worth about $1.40 per gallon. The first increment of the motor fuel market is for about one billion gallons of alcohol which can be utilized for premium unleaded gasoline. A billion gallon market would support 20 — 25 plants of economic scale. Our industry can build plants at this scale which utilize our commodity handling skills, as well as advancing engineering and operational technology. The corn volume demand for a billion gallons would be 400 million bushels, an increase of almost 80 percent over the 1980 usage of the wet corn millers for existing products. While the development of a 400 million bushel industry might not have a significant impact on the marketing of a

7 billion bushel crop, the marketing of an 80 percent increase in feed co-products could have significant repercussions on feed markets and the basic economics of corn conversion.

The traditional non-food applications of starches and sweeteners utilize about 20 percent of the wet corn milling industry grind, or about 90 million bushels of corn. Most of the industrial usage is as starch, and most of that is in the paper related industries. The markets for these products are relatively specialized, and much of our production is tailor-made for specific applications. The development and sale of products for these applications has required a high commitment to and investment in research and technology. The paper industry depends upon starches for paper strength, surface sizing and coating.

Starch based products supply the bulk of the adhesives for paper bags, folding cartons and corrugated boxes. Starches are also important to the building industry as wallboard binders and joint cements. Cotton textiles depend upon starch for warp sizing. The mining industry uses starch for drilling muds. Research continues to improve the performance of starches in all these applications, but further growth is dependent upon the futures of these user industries.

Fuel alcohol now promises to become the largest non-food application for agricultural commodities. During 1979 and '80, goals of 1 to 10 billion gallons per year were set by various government agencies, and numerous financial incentives were placed to encourage construction of new capacity. The emphasis was upon national energy independence rather than straightforward economics. The current energy values of some of our common fuels are:

Crude oil @ $32/bbl.	$ 5.50/M BTU
Natural gas	$ 3.10/M BTU
Refined gasoline @ $1.35/gal.	$10.80/M BTU
Alcohol @ $1.80/gal.	$21.40/M BTU

Alcohol is simply not cost competitive today as a motor fuel extender. However, the need for alternative fuels is real. Fossil fuels are an exhaustible resource. Drilling activity in the U.S. is at a record rate with over 4,000 rigs in operation, which will drill close to 70,000 wells this year. Oil prices since decontrol are at record highs, encouraging maximum production. Yet the American Petroleum Institute estimates that 1981 production will show no increase over 1980. The whole drilling effort is approaching a state of diminishing returns, with new discoveries and production barely offsetting depletion.

Conservation and a slow economy have reduced demand, but our dependence upon imports continues at nearly 6 million barrels per day, roughly 40 percent of our supply. The vulnerability of this supply was demonstrated twice during the 70s.

We have very large reserves of coal and oil shale. However, the problems of converting these materials to useful liquid fuels are almost overwhelming. The processes require huge investments, new complex technologies still untried at practical scale, large quantities of water in already water deficient areas, and environmental problems of unprecedented magnitude.

The multi-billion dollar plant construction schedules run from three to seven years. Economically, they face the syndrome of the receding breakeven point. That is, energy costs bear so heavily on the general inflation of construction and operating costs, that each increase in petroleum price requires the assurance of a subsequent increase to make the project profitable.

The production of alcohol from grain utilizes proven technology, and economy of scale can be achieved in relatively small (40 million gal./yr., $100 million) plants which can be operational from a grassroots site in 20 to 30 months.

Although gasoline consumption is expected to decrease, the requirement for unleaded fuel continues to grow, and may approach five million barrels per day by 1985. This will require at least a 2 point increase in the clear octane pool. Since alcohol has an octane value over 100, it is of interest as an octane enhancer rather than a simple fuel extender.

A number of chemicals are available for octane boosting. Currently the largest volume octane enhancers are the aromatics which are produced by the hydroforming operation at a petroleum refinery. The aromatic compounds are not actually isolated and purified but become a part of the finished fuel. There is a significant loss in yield in the reforming process of roughly 20 percent. When gasoline is in short supply, automobile manufacturers will be calling for higher octanes for better fuel economy while the refiners are burning up increasing quantities of their raw material in order to achieve these octane numbers. Thus, the substitution of ethanol as an octane enhancer offers the added incentive of increased refinery yield. Currently, mixed aromatics are worth about $1.40/gal., and ethanol about $1.80. With a 40¢/gal. federal excise tax rebate, ethanol becomes competitive with the aromatic compounds.

At the present state-of-the-art, corn or grain sorghum provide the lowest cost fermentation raw material. Agricultural waste, such as straw and stover, have the potential of competing if they can be supplied to a processing plant at $25 to $30 per ton, but commercial technology is probably two to five years away. It would seem that these materials, and perhaps wood chips, would first establish themselves as solid fuels, where it is feasible to substitute them in stationary applications for other solid or liquid fuels. For example, on-farm corn dryers use propane at 63 cents a gallon or $6.90 per million BTUs which is roughly equivalent to a value of $110/ton for their stover.

There are other potentials for recovery of markets that have been lost to petrochemicals. Citric acid production could utilize up to 300 million pounds of dextrose per year, equivalent to 10 million bushels of corn. Less than one-half of this potential is now corn-based, with the remainder as molasses and petroleum-based substrates. The largest citric acid plant in the U.S. was designed to use a paraffin-based substrate. It has been since modified to utilize dextrose.

Synthetic, petroleum-based detergents have displaced animal and vegetable fats in soaps. However, as petroleum prices increase, sugar or starch based surfactants may have a new opportunity. Tate & Lyle, a British firm, has licensed a commercial scale plant to Japan. The U.S. market for detergent base organics is about one billion pounds per year. This market could provide our next growth phase in the late '80's and early '90's.

Acetic acid is another case of market lost to cheap petrochemicals. The early production came from the fermentation of alcohol to vinegar. Alcohol has been displaced by a process for synthesis from CO and methane. As natural gas prices increase, there will be new opportunities for coal based synthesis gas, or even corn based fermentation alcohol as raw material. The plastics industry now uses over three billion pounds of acetic acid per year in the manufacture of such well known items as vinyl acetate, terephalates, and cellulose acetate. This large non-food market, which is equivalent to 360 million gallons of ethanol, may also be a long time away.