
STRATEGIC REVIEW OF GLOBAL CORN STARCH INDUSTRY & MARKETS - STARCH DERIVATIVES, SWEETENERS, CO-PRODUCTS AND BIOPROCESSING  August, 2012

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This report is a comprehensive document with detail information and industry data along with description of how industry or plants are managed. Report includes detail review of several areas that cannot be found in other publications. It is also a very informative representation of production, markets, products, costs, capacity and the players in the US. The data sets of sweeteners, starch derivatives, co-products and the impact of trade regulations are provided. None of this is available in any currently marketed reports, as we have attempted to compile in this report. In the last section of report is a complete list of plants of small to large global players of this industry. We provide deep insights into how this industry operates its costs, products and markets; an insider’s view with almost 100+ yrs. of experience of our associates. Our expertise in technology and marketing includes several aspects of this industry, several assignments in the operations, research and development; marketing and technology transfer in the U.S. and Europe. A great tool for current and future processors, suppliers, customers and an excellent resource to train new professionals in various functional departments within an organization or those who desire to enter this industry.

1. This newly revised starch processing report has several improvements, new information, insights since we are now in a global economy. In 2012 report we have made major changes to this report to reflect several changes in the US and worldwide. Every chapter has been updated with much new information, insights and data. Some of the major changes and additions are:

- CWM (Corn wet milling) co-products technical and commercial perspective including potential markets for corn gluten feed (CGF), corn gluten meal (CGM) and corn germ.
- A new chapter focused on corn ethanol, Chapter IX
- Bioprocessing, bio-based chemicals and bioplastics chapter X has the most recent information with markets, capacities and opportunities for bio-based chemicals and polymers from starch and the sugars as feedstock. CWM players have entered arena of converging their facilities in to biorefineries with products such as ethanol, lactic acid, citric acid, amino acid lysine, and other monomers for new value added polymers to replace the petroleum based compounds.
- Each chapter also has major revisions to reflect most recent information on the business, markets and technologies as we continue to evolve in this global carbohydrates economy.
- Brand new list of starch and sweeteners manufacturers from corn, wheat, potato and tapioca primary starch crops in different regions of the world.
- A great addition to the library as reference, training tool and a strategy tool to starch processing industry members, customers and suppliers.
- Report also has excellent in-depth insights from our associates and I with combined experience of > 200 yrs in starch/sweetener and bioprocessing.
- New global list of starch processors is provided in Chapter XVI.
Several updates to each chapter to reflect current situation and opportunities going forward.

2. Europe remains in recession, US is coming out of the worse recession and emerging markets of the BRIC countries including China seem to show some slowdown for the strong growth we have seen in the past few years. As the developed economies stabilize, and start growing above anemic 1-2% to 2-3%; there will be great opportunities for starch processing industry especially to fulfill the demands of new developing economies in Asia, South America, Russia and Africa. This executive summary is an introduction to this report and not compilation of sections of each chapter as presented in other similar reports, we do not want to duplicate the contents of chapters.

3. As indicated, this report remains a comprehensive leading document that has industry data along with description of how industry or plants are managed. It provides in-depth review of several areas that cannot be found in other publications. There are many details of production, markets, products, costs, capacity, players in the US and data sets of sweeteners, starch derivatives, co-products including the impact of trade regulations. We remain closely connected to this industry maintaining good industry communications. None of this is available in a reports format as we have attempted to compile in this report. In the last section of report is a complete list of global players of this industry.

7. For 2011 we estimate the total utilization of dried starch in the world was ~71 million tons (USDA, EU Commission). We previously estimated this would reach 70 million tons by 2010, China and some of the emerging markets added most to the growth. China had the biggest growth with ~19 million tons (including ethanol) production in 2011 with growth of 7% over 2010. The US, EU and Japan has lower growth of ~2%/year, EU at ~2%, and Japan at 1-2%. Going forward the growth in China and India will slow down to 6-7%; the rest of the world grows at 2-4%. Most of the 4% growth came from ethanol from the wet milling operations. We estimate that total starch production from major starch crops will be 81.3 million tons by 2015.

9. There are only few starch processors left in the US and even ADM and Cargill are positioning themselves in EU and Asia. Ingredion remains a dominant specialty player in the US. Cassava in SE and S Asia and Central America will become more dominant starch commodity as more production technology is deployed. Cassava is 7.5% of world starch. This figure will have been rising faster as China, India, South America and SE Asia continue to improve their production economics. Above values do not include corn utilization for dry grind corn ethanol which more than double of corn used for corn wet milled products derivatives.

12. For 2012 USDA estimate 95 million corn acres of corn to be planted, a record in recent years. However the situation has changed at the completion of this report in July, 2012. Continuing deterioration of the U.S. corn and soybean crops was evident in the latest Crop Progress data from the U.S. Department of Agriculture for the week ended July 22. Spring wheat crop conditions declined modestly as well. In the 18 major corn growing states, a total of 26% of the corn crop was rated good to excellent, down from 31% the previous week, the U.S.D.A. said. The proportion of the crop that was very poor to poor surged to 45% as of July 22, up from 38% in the previous week. A year ago in the same week, 62% of the crop was rated good to excellent and only 14% was very poor to poor. The worst drought in decades in >50 yrs. is striking a serious blow to ethanol industry -- Sep corn prices have now soared by 62% in the past 5 weeks from $5.095/Bu on June 15 to $7.86/Bu end of July.

14. Current as of July, 2012; situation on corn ethanol is changing. Skyrocketing corn prices related to this summer's drought have helped to idle an Indiana ethanol plant in Montgomery County, while Cardinal Ethanol at Union City and POET Biorefining in Portland and Alexandria...
remain at full production. Valero Energy Corp. idled its plant in Linden, between Lafayette and Crawfordsville, late last month but is keeping its 60 employees on the payroll and intends to re-start production before harvest. "High corn prices driven by the drought have caused some ethanol plants to temporarily idle or reduce production," Matt Hartwig of the Renewable Fuels Association, an ethanol trade group in Washington, D.C., told The Star Press. "Ethanol prices have not kept pace given the overhang (ethanol surplus) in the market. It's made for some tough margins in the industry of late. The drought conditions will make it tough on all end users of corn and the market will ration supply accordingly." If corn goes up to 10 $/Bu, more plants will probably shut down over a series of weeks. Corn is their biggest cost.

16. During 2010/11, CPI acquired National Starch which enhanced its modified starch portfolio to >30 % from < 5 % worldwide. CPI also renamed itself as INGREDION reflecting the ingredients business. CPI/National starch combination presents a very strong potential, combining CPI’s supply chain, global presence and National's strong specialty starch portfolio.

17. Companies such as Roquette America are investing in a world-class Science & Technology campus indented for customers to create new products and enhance existing ones for the Nutrition, Pharmaceutical, Nutraceutical, and Bio-Chemical market segments.

19. What follows is an analysis and presentation of data along with insights into several aspects of this industry based on experience of my associates and me, which included several assignments in the operations, research and development; marketing and technology transfer worldwide. This is a comprehensive report with lot of data and insights in to how this industry operates and how one can position in the changing global markets. Report has business, technologies, costs and market data that can serve as a tool to develop strategy to enter this industry globally. This report has also served as an excellent resource for industries that do business with corn processing industry, a training tool for operations, marketing, purchasing and R & D groups.

Sakharam K Patil, Ph. D. S. K. Patil & Associates August 2010

### III. Markets

#### A. Food & Beverage Market Profile

- According to Plunkett Research, in 2010 the U.S, the retail grocery store and supermarket industry, with 40,000 stores, totaled about $508 billion in revenues during 2011, according to U.S. Department of the Census figures. However, food products in America and elsewhere are sold at a wide variety of stores other than supermarkets. To get the full picture in the U.S., it is important to consider the $371 billion in sales at 52,000 non-traditional stores such as wholesale clubs and dollar stores, as well as $175 billion at 117,000 convenience stores (not including convenience store gasoline sales).

- In aggregate, the world starch market was estimated to be 63 million tons in size in 2007, this has now grown to ~ 71 million tons including not only native and modified starches, but also large volume of starch that is converted in recent years into ethanol; and various sweeteners such as HFCS, substrates for other products such as organic acids, chemicals and ethanol. China, India, Brazil and Russia have driven this growth. The
value of the output of this industry is worth in excess of 20 billion dollars. The US has the largest starch industry, with almost 1/3rd of the world production. Europe accounts for 17 to 18 % of the output. Table 3 depicts the relative sizes of the starch productions of the US, EU, China and the rest of the world. We estimate that total starch production from major starch crops will be 81.3 million tons by 2015

- Bioprocessing, bioethanol and in foods the health/nutrition driven products, the bulk commodities such as flour, whole grain, starch derivatives with specific nutritional attributes for diabetes, digestibility, slow/controlled energy for mainstream staples such a bread, soups, etc will drive the demand for commodities ingredients worldwide.

### F. Analysis of Strengths and Weaknesses of Players (SWOT)

Figures 26 and 27 provide some sense of commodity/specialty product mix and the volume/profitability for each CWM players. Table 34 is a summary of the strengths and weaknesses of all corn refiners in the US, including the non-members of CRA. This is purely based on some observations and should not be misconstrued as official position of any organization. Some of the comments are discussed above in detail.
Table 34 SWOT of US corn processors

Cargill

**Strengths**
- Cargill has excellent diversified portfolios in sweeteners, modified starches, health/nutrition ingredients including dietary fibers, erythritol, sucromalt, stevia and many others. Provides good flexibilities in many food and industrial markets worldwide.
- Cerestar offers a strong position in modified starches, specialty syrups and polyols in Europe & US
- Strong position in sweeteners (HFCS), Feeds and other commodities e.g. steel, salt, chocolate, etc

**Weaknesses**
- Some issues with their corporate platform and business units, however this privately held company manages to grow in several markets
- Perceived commodity company
- Managing very large company and to transition into specialties is difficult
- Business units issues

VI. Costs, Investments and Margins

A. Product Profitability

The discussion on profitability of some of these products is provided in this section. Earlier section III has presented the markets for modified starches and the estimated prices for major categories of different products and for food and industrial segments. As stated in previous pages, this industry produces a range of products for food and industrial applications. Thousands of food products use corn sweeteners and starch products. This is also true in the case of non-food industrial products such as paper, paints, adhesives, etc. The functional properties were also briefly described in the earlier sections.

**Most Profitable Products in the Industry**

This section provides the estimate of margins of major categories of food ingredients from corn processing. Following is a list of examples of profitable products in the order of their profitability.

**STARCH**
- Pre-gelatinized, CWS (cold water soluble), high amylose and spray dried
- Food grade waxy ethers
The discussion on profitability of some of these products is provided in this section. Earlier tables 8 and 9, in section III provide the estimated prices for different products.

This industry produces a range of products for food and industrial applications. Thousands of food products use corn sweeteners and starch products. This is also true in the case of non-food industrial products such as paper, paints, adhesives, etc. The functional properties were briefly described in the earlier sections.

**Most profitable products in the Industry:**

Table 30 in this section provides the estimate of margins of major categories of food ingredients from corn processing. Following is a list of examples of profitable products in order of their profitability.

**Table 36   Approximate cost (dollars) estimates per CWT (100 lbs) 2008 Est.**

<table>
<thead>
<tr>
<th>Cost Activity (estimates)</th>
<th>HFCS</th>
<th>Modified-oxidized or ethylated starch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Corn cost per CWT of finished product</td>
<td>11.1 = (3.7 x 3.0)</td>
<td>11.84 = (3.7 x 3.2)</td>
</tr>
</tbody>
</table>

Detail explanation of cost calculation in the report
VII. Industry Capacity

A. Capacity Utilization Issues

In the investment planning stage, the product mix decisions are affected by many factors and economy of scale is a significant one. The size of the front end of the plant—the wet milling portion of the plant—i.e. the steeping, grinding, and separation unit operations—determines the overall capacity and product mix flexibility depends upon how much the investors are willing to spend on finishing capacity.

E. Incremental Capacity

The capacity increase starts with the milling process, which is common to all the finishing channels. Any capacity increase in a given product line must balance with what the mills can supply as a starch slurry or raw material and the desired finished product downstream. Following are few scenarios.

Steep, mills, separation and washing equipments are added for given capacity. In the finishing channels the reaction tanks, pumps, washing batteries, dryer supply tanks and........

VIII. Corn Wet Milling Co-Products Current Situation and Potential Markets

A. CWM Co-products Introduction

Increased co-product production from wet and dry mill ethanol is ~ 35 million tons in 2011 (estimate) is the results of growth of mainly ethanol, industrial fermentation and potential large volume starch products. This is an increase of 25 million tons from 2006. We estimate CWM industry produced 4.7 tons CGF of the total 35 million tons co-products from combined CWM and dry mill ethanol (Table 45) in 2011. This table is repeated again in Chapter VI Corn Ethanol to emphasize the co-products from dry grind and wet milled ethanol.

IX. Corn Ethanol Brief Review

A. Ethanol

Biobased Products and Biorefineries

Biobased products from corn using the corn refining industry and other similar bioprocess technologies from the renewable plant and ocean sources are most promising growth areas globally. The most striking examples are ethanol for fuel and food sweeteners, HFCS and range of corn syrups. Besides these high volume commodity products corn wet milling and refining plants have been transformed into highly sophisticated bioprocess operations that produce range of products (listed in Corn Annual) such as citric acids, lactic acids, lysine, threonine, xanthan gums, erythritol, sorbitol, xylitol, mannitol, hydrogenated starch hydrolyzates, maltodextrins, glucose hydrolyzates and the most recent nutritional products Sucromalt (more on this later). DuPont’s 1, 3 propendiol (PDO) a monomer for 3 GT polymer an alternative to synthetic fiber and Cargill Dow’s polylactate for biodegradable film to replace plastic film are other examples that can replace petroleum based products, there will be many more to come as we make the science work for us.
X. Bioprocessing: Fermentation, Specialty Chemicals, Bioplastics - Current Situation and Opportunities

Bioprocessing facilities integrate biomass conversion processes and equipment to produce fuels, power, and chemicals from biomass. The biorefinery concept is analogous to today's petroleum refineries, which produce multiple fuels and products from petroleum. Industrial biorefineries have been identified as the most promising route to the creation of a new domestic biobased industry.

By producing multiple products, a biorefinery can take advantage of the differences in biomass components and intermediates and maximize the value derived from the biomass feedstock. A biorefinery might, for example, produce one or several low-volume, but high-value, chemical products and a low-value, but high-volume liquid transportation fuel, while generating electricity and process heat for its own use and perhaps enough for sale of electricity. The high-value products enhance profitability, the high-volume fuel helps meet national energy needs, and the power production reduces costs and avoids greenhouse-gas emissions.

XI. Future Trends

A. Technological Developments

Carbohydrate-based products have the potential to improve the sustainability of natural resources, environmental quality and national security while competing economically to expand the U.S. and world industrial base. Biobased products have a wide range of uses in energy and intermediate chemicals for food, industrial, consumer and pharmaceutical applications. Agriculture crop producing rural areas are well positioned to support regional processing facilities dependent on locally grown crops.

Corn refineries/possessing capabilities comprise the front end of an industrial complex that produces food, specialty chemicals, industrial products, fuels and pharmaceuticals. Such an expanded biorefinery would provide cleaner and more economical processes for producing existing products, new intermediates for manufacturing new products, and an expanded stable market for wet millers and for corn farmers. A large corn wet-milling plant with its own steam and electric cogeneration station can form the nucleus for several other plants. The wet mill is the source of materials for plants that produce industrial enzymes, organic acids, amino acids and ethanol. The enzymes are then used to convert starch to lower molecular-weight products, principally various maltodextrins and syrups. The organic acids are used in processed foods, detergents, and polymers. The amino acids are used as feed and food supplements and, in the case of phenylalanine, to make aspartame. The ethanol is used as a fuel or an industrial solvent. Some detail thoughts and insights as follows:

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