

S.K. Patil & Associates, Inc  
 1403 Coventry Lane  
 Munster, IN 46321  
 Tel/Fax: 219.922.1033  
 Cell: 574.210.5876  
[sakharam@sbcglobal.net](mailto:sakharam@sbcglobal.net)  
[www.skpatilassociates.com](http://www.skpatilassociates.com)

## S. K. Patil and Associates, Inc

### ***CORN STARCH INDUSTRY PRODUCTS, COSTS & MARKETS - STARCH DERIVATIVES, SWEETENERS, CO-PRODUCTS & BIOPROCESSING*** November, 2014



*By: S K Patil & Associates, Inc.  
 November 2014*

***CORN STARCH INDUSTRY PRODUCTS, COSTS & MARKETS - STARCH DERIVATIVES,  
 SWEETENERS, CO-PRODUCTS & BIOPROCESSING*** November, 2014

#### **TABLE OF CONTENTS**

<b>I. EXECUTIVE SUMMARY .....</b>	<b>6</b>
<b>II. BRIEF OVERVIEW OF CORN AND WET MILLING PROCESS .....</b>	<b>10</b>
A. CORN .....	10
B. OVERVIEW OF CORN WET MILLING PROCESS .....	12
<b>III. MARKETS .....</b>	<b>16</b>
A. FOOD & BEVERAGE MARKET PROFILE .....	16
B. STARCH PRODUCTS SITUATION AND FORECAST .....	18
C. PERSPECTIVE: CWM INDUSTRY AND WHERE WILL THE GROWTH COME FROM? .....	24
D. POTENTIAL CHANGES AND MARKET DRIVERS .....	32
E. NATIVE AND MODIFIED STARCH PRODUCTS OVERVIEW .....	33
F. OVERVIEW OF MODIFIED STARCHES .....	36
G. MODIFIED STARCH MARKETS .....	45
<b>IV. SWEETENERS AND MALTODEXTRINS .....</b>	<b>56</b>

A. SWEETENERS .....	56
B. CORN SYRUPS – HFCS (HIGH FRUCTOSE CORN SYRUP) AND OTHER SYRUPS .....	56
C. MALTODEXTRINS .....	65
<b>V. COMPANIES IN THE US .....</b>	<b>70</b>
A. COMPANIES AND PRODUCTS .....	70
B. CONSOLIDATION IN THE STARCH INDUSTRY .....	72
C. PRODUCTS MANUFACTURED BY CORN REFINERS .....	75
D. INDUSTRY CHOICES TO SUPPLY STARCH FOR POTENTIAL LARGE NEW APPLICATION ...	77
E. CWM (CORN WET MILLING) INDUSTRY MAJOR PLAYER’S OBSERVATIONS .....	78
F. ANALYSIS OF STRENGTHS AND WEAKNESSES OF PLAYERS (SWOT) .....	85
G. PLAYERS - OTHER DIFFERENCES (SEE V – E ABOVE) .....	92
H. INVESTMENT RISK AND DECISIONS .....	92
I. R & D INVESTMENTS .....	94
<b>VI. COSTS, INVESTMENTS AND MARGINS .....</b>	<b>97</b>
A. PRODUCT PROFITABILITY .....	97
B. COST OF PRODUCTION .....	98
C. MARGINS AND OVERHEAD .....	100
D. MANUFACTURING METRICS .....	102
E. COST CALCULATIONS AND PRICING INFORMATION .....	103
F. SHIPPING AND TRANSPORTATION .....	104
G. GOVERNMENT POLICIES AND ITS EFFECT ON PRICE .....	105
H. PROCESSING ASSETS AND IMPLICATIONS ON THE MANUFACTURING .....	108
4	
<b>VII. INDUSTRY CAPACITY AND INVESTMENT .....</b>	<b>111</b>
A. CAPACITY UTILIZATION ISSUES .....	111
B. EFFECT OF CAPACITY UTILIZATION ON COSTS .....	111
C. NEW POTENTIAL CAPACITY .....	112
D. CO-PRODUCTS MANAGEMENT - CWM .....	114
E. INVESTMENT .....	115
F. INCREMENTAL CAPACITY .....	117
G. SMALLER INCREMENTS .....	118
H. CAPITAL ASSOCIATED WITH THE INCREMENTAL BUSHEL PROCESS .....	118
I. CAPACITY BY PLAYERS IN THE US .....	119
J. HISTORICAL PERSPECTIVE OF CAPACITY INCREASE .....	122
K. STARCH AND ETHANOL ASSETS INTERCHANGEABILITY .....	122
<b>VIII. CORN WET MILLING CO-PRODUCTS CURRENT SITUATION AND POTENTIAL MARKETS .....</b>	<b>125</b>
A. CWM CO-PRODUCTS INTRODUCTION .....	125
B. CORN GLUTEN FEED (CGF) .....	128
C. CORN GLUTEN MEAL .....	133
D. CORN GERM AND OIL .....	137
E. ZEIN PROTEIN .....	139
3	
<b>IX. CORN ETHANOL BRIEF REVIEW .....</b>	<b>143</b>
A. ETHANOL .....	143
B. GROWTH OF FUEL ETHANOL AND ITS EFFECT ON THE INDUSTRY .....	148
C. CO-PRODUCTS .....	152
<b>X. BIOPROCESSING: FERMENTATION, SPECIALTY CHEMICALS, BIOPLASTICS -</b>	

<b>CURRENT SITUATION AND OPPORTUNITIES .....</b>	<b>154</b>
A. CORN AS A CHEMICAL FEEDSTOCK .....	155
B. BIOPROCESSING AND FERMENTATION .....	158
C. BIOPLASTICS .....	162
D. SOME EXAMPLES OF RECENT DEVELOPMENTS BY STARCH PROCESSORS AND OTHER COMPANIES .....	172
<b>XI. FUTURE TRENDS .....</b>	<b>178</b>
A. TECHNOLOGICAL DEVELOPMENTS .....	178
B. BUSINESS, TECHNOLOGY TRENDS AND ISSUES THAT WILL IMPACT CORN PROCESSORS TRENDS .....	179
C. STARCH PRODUCTS AND TECHNOLOGY DEVELOPMENTS FEW EXAMPLES .....	181
D. BIOTECHNOLOGY (MODIFIED STARCHES, EFFECT ON YIELD AND PRODUCTION COSTS)	184
E. IMPROVEMENT OF STARCH YIELD AND EXTRACTION .....	185
F. PATENT SCAN AND NEW OPPORTUNITIES .....	186
G. MARKET DEVELOPMENT OF CO-PRODUCTS .....	186
H. GMO TECHNOLOGY EFFECT ON THE IMPORT/EXPORT .....	187
5	
<b>XII. GLOBAL ISSUES, POLICIES AND PLANT LOCATIONS .....</b>	<b>188</b>
A. US AND MEXICO TRADE ISSUES – SUGAR AND HFCS .....	188
B. GOVERNMENT POLICIES AND POTENTIAL EFFECT ON THE PRICES .....	188
C. DUTIES AND SUBSIDIES .....	191
D. OPPORTUNITIES AND POTENTIAL BENEFITS OF MANUFACTURING LOCATION DUE TO DUTIES, SUBSIDIES AND INVESTMENT INCENTIVES .....	194
<b>XIII. SUMMARY .....</b>	<b>197</b>
<b>XIV. LIST OF REFERENCES .....</b>	<b>200</b>
<b>XV. LIST OF FIGURES AND TABLES .....</b>	<b>202</b>
<b>XVI. GLOBAL LIST OF CORN PROCESSORS .....</b>	<b>205</b>

## **I. Executive Summary**

**A.** This newly revised starch processing report has several improvements, new information, insights since we are now in a global economy. In 2014 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: Newly updated CWM (Corn wet milling) co-products with 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. Other chapters revised to reflect current situation, opportunities and outlook to 2017. Information gathered from various public sources and private estimates 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 > 100 yrs in starch/sweetener and bioprocessing. New global list of starch processors is provided in Chapter XVI. Global List of Corn Processors p 205.

**B.** 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.

**C.** 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.  
More.....

### **III. Markets**

#### **A. Food & Beverage Market Profile**

According to Plunkett Research, in 2013 the U.S, the retail grocery store and supermarket industry, with 40,000 stores, totaled about \$650 billion in revenue. Food sold via restaurant is 552 billion dollars. 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 \$431 billion in sales at 57,000 non-traditional stores such as wholesale clubs and dollar stores, as well as \$175 billion at 150,000 convenience stores (not including convenience store gasoline sales).

In retailing, supermarkets are changing as chains construct larger stores in a variety of formats. Mergers among chains have led to increased concentration. Wal-Mart is the largest food retailer giving this company an enormous buying power.

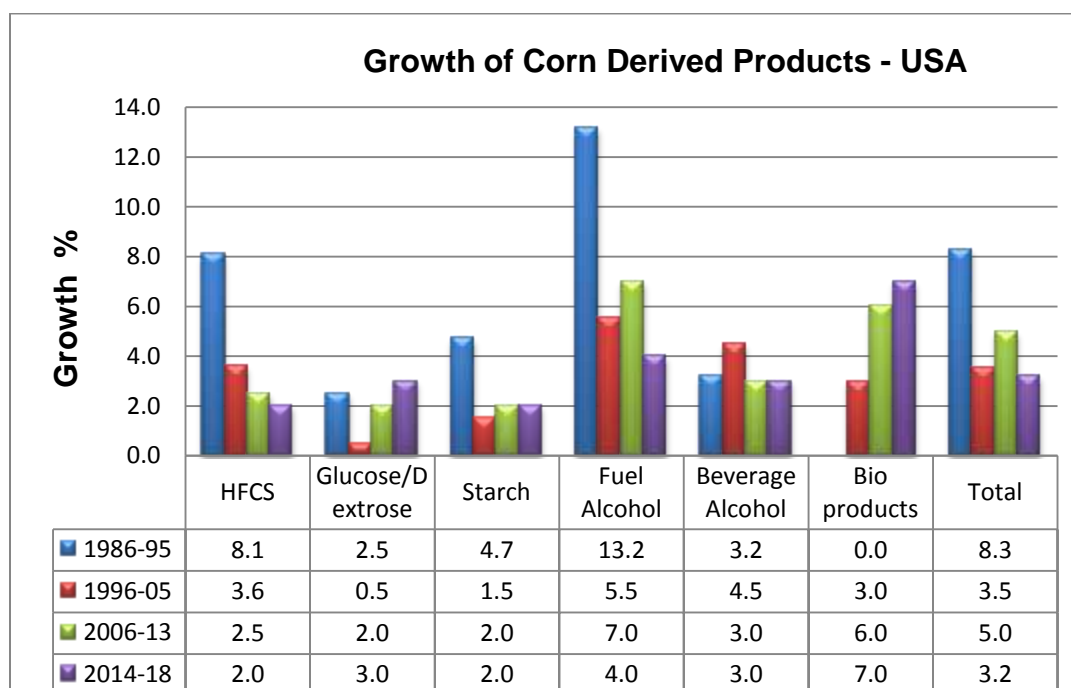
#### **C. Perspective:**

##### **CWM Industry and Where Will the Growth Come From?**

The recent economic situation with very strong growth in ethanol; even with general flattening including reduction in the use of HFCS has increased the demand on corn supply attributed to ethanol growth. Starch usage remains stable in food; the paper industry slowdown has reduced industrial starch demands. This will continue in the next few years. Ethanol is growing very fast with almost 212 dry mill ethanol plants in operation or in the plans as of 4th quarter 2013. Congress recently (end of 2013) voted to maintain ethanol levels to 15 billion gal. by 2015 and the total biofuels to 36 billion gal. by 2013.

Recent shut down of Memphis Tenn. Facility by Cargill has removed almost 2 billion lbs of sweeteners (mainly HFCS), unmodified and certain modified starches have maintained supply demand balance along with stable prices even with record corn production and significantly lower cost prices. Penford was acquired in Jun. 2015 by Ingredion making Ingredion a largest manufacturer of specialty modified starches. A new small player High Plains Milling has entered this industry by re starting Cargill's Dimmit, Texas facility.

Figure 8: Average Annual % Growth of Major Corn Derived Products



### Economy of Scale and Investment Decisions

Large refineries producing commodity products strive to be the lowest cost producer. Primary contributors to production costs, excluding raw material costs, are those related to investment, labor, and conversion. Investment related costs include maintenance, insurance and property tax, and general plant costs. Doubling the plant capacity generally increases investment required by only 50 percent, so costs per unit of production decrease with plant size. In a simplistic sense, one operator can run a process whether the unit produces a thousand liters/minute, or two thousand liters/minute, thus unit labor costs decrease as production capacity increases. Conversion costs include utilities such as steam, electricity, and water, which are generally insensitive to volume on a cost per pound basis.

### 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/opportunities

#### Agricultural expertise

Cargill's significant expertise in the agricultural supply chain is a major advantage when it comes to food ingredients, while ties to the farming industry also help facilitate sourcing.

### Weakness/threats

#### Mature core ingredients

A number of Cargill's core bulk ingredient markets are mature and relatively slow growing, thus placing emphasis on the need for new value-added solutions and innovation.

## 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.

- Pre-gelatinized, CWS (cold water soluble), high amylose and spray dried
- Food grade waxy ethers
- Food grade certain esters
- Ionic – Amphoteric and cationic
- Ethylated
- Oxidized
- Clean Label Starches
- other

### Most profitable products in the Industry:

Table 36 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.

Figure 14: Modified food starch market share by US starch processors – 2008

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

Cost Activity (estimates)	HFCS	Modified-oxidized or ethylated starch
Net Corn cost per CWT of finished product	11.1 =(3.7.0x3.0)	11.84 =(3.7x3.2)

Detail explanation of cost calculation in the report

Explanations Table 36:

(Gross corn)- (Co-product credit) = Net corn

(Gross Corn= \$4.0 minus Co-product credit=\$1.40) = Net corn Cost of \$ 2.60/Bu (used in Table 36 above) MORE.....

## **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

.....

## **X. 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 propandiol (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 integrates 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.

## **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. Besides sweeteners and starch derivatives 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. Much detail with our insights with a lot of pertinent data are presented.

S K PATIL & ASSOCIATES, Inc.  
MUNSTER, IN 46321  
219-922-1033  
sakharam@skpatilassociates.com  
www.skpatilassociates.com

November 2014