

## **Converting Corn Fiber into Products from A to Z: Amaizing Oil and Zeagen Corn Fiber Gum**

### **ABSTRACT**

Research at the Eastern Regional Research Center, ARS, USDA in Wyndmoor, PA has led to the discovery of valuable new co-products from corn fiber, an underutilized byproduct from corn wet-milling operations. Two new products, Amaizing Oil (a new natural edible oil) and Zeagen (a natural food and industrial gum) were developed at ARS facilities and are now being commercially developed through Cooperative Research and Development Agreements (CRADAs) with industry partners. Commercialization of both co-products will lower the cost of wet-milled derived products (including fuel ethanol), create new opportunities for growers, processors, and manufacturers, and provide new American made, health-promoting products for U.S. consumers.

Keywords: Corn fiber, new uses, nutraceuticals, food gums, phytosterol esters

### **INTRODUCTION**

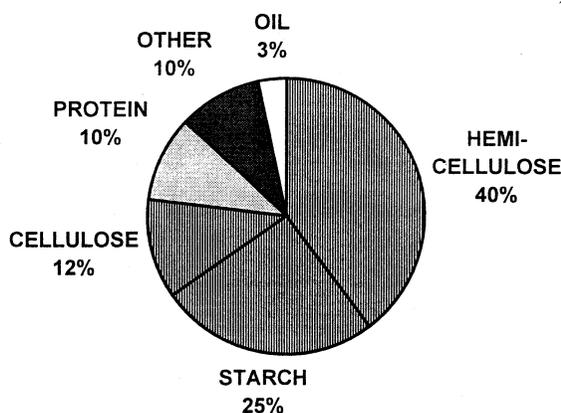
Our research in corn fiber utilization began in 1994 when the Agricultural Research Service was asked to find ways to lower the cost of corn-derived fuel ethanol. Some ARS research teams approached this goal by discovering more efficient processes for fermentation and ethanol recovery (1,2) while others developed novel means to increase the overall yield of ethanol from a bushel of corn by converting the residual corn fiber into ethanol (3). Our approach was to convert the low-valued byproducts from traditional corn-to-ethanol processes into higher valued co-products. The new revenue generated from co-product sales could lower the overall cost of fuel ethanol without requiring major changes in current ethanol production facilities. We chose to work on finding new uses for the “corn fiber” byproduct that is generated in traditional wet-milling operations that produce most of the fermentable sugars used in US fuel alcohol production.

#### **Corn Fiber: Its Composition and a Rationale for Developing New Uses/Products**

It is estimated that from 4 to 5 million tons of corn fiber are produced each year by US wet milling facilities (4). Its current primary use is as a component of corn gluten feed, an inexpensive (\$.03-.05/lb) animal feed ingredient that is largely exported. Corn fiber from wet milling operations usually consists of kernel pericarp, tip cap, and endosperm-derived cell wall materials as well as residual starch and other components as shown in Figure 1. Successful attempts at developing new co-products from corn fiber will focus on finding unique and valuable uses for its components. We chose to develop products derived from

hemicellulose, the major component, because of its abundance and unique properties, and from oil, a minor and overlooked component for reasons that will become obvious below.

Fig 1. APPROXIMATE COMPOSITION OF CORN FIBER



### ***Amaizing Oil***

The amount of oil in fiber (2-4%) had been considered to be insignificant except for the digestible energy it provides in animal rations. Most researchers had surmised that the low level of oil arose from traces of corn germ, the kernel component from which commercial corn oil is presently extracted. Regardless of the origin, the prospect of economically extracting 3% oil from fiber curtailed serious efforts to extract or study this fraction. However, at the start of this project, Dr. Robert Moreau, lead investigator on the oil-co-products project, learned that two researchers at ARS's National Center for Agricultural Utilization Research in Peoria IL, had noted (5-7) the presence of phenolic phytosterol esters in corn bran (the fiber fraction from dry milling of corn). These esters were structurally similar to "Oryzanol," a class of phytosterol esters present in rice bran oil that had been reported to lower serum cholesterol levels in hamsters (8) primates (9), and humans (10). Research at Wyndmoor led to the first extractions and study of a new "corn fiber oil" that was later termed "Amaizing Oil". Methods for the extraction and quantitative analysis of the major components in Amaizing Oil have now been developed (11). The oil can be extracted with solvents such as hexane, ethanol, isopropyl alcohol, or supercritical carbon dioxide. Composition of the oil can be significantly affected by the particle size and the source of the fiber. For instance, oil from corn fiber appears to be superior to that from corn bran (12). Selection of proper conditions can result in the extraction of at least 2% yields of oil containing significant levels of three potential cholesterol-lowering components: sitostanol-ferulate (4-6 %), free phytosterols (1-2%) and phytosterol-fatty acyl esters (7-9%). The extraction process was scaled up by Dr. Robert Hron of ARS's Southern Regional Research Center in New Orleans, LA, providing enough oil for animal feeding studies. Preliminary studies at the University of Massachusetts in 1995 indicated that this oil lowered the levels of total serum cholesterol and LDL cholesterol in hamsters (13).

***Amaizing Oil Market Size and Competition.*** The market size for a natural cholesterol-reducing oil is substantial. In 1995, Raisio Group in Finland introduced Benecol

margarine, containing a semi-synthetic sitostanol-fatty acyl ester prepared from tall-oil, a by-product from the wood pulping industry. Benecol has been shown to reduce cholesterol levels in human clinical studies (14). Benecol sells for a reported \$9.00 per pound with 1996 sales in Finland totaling \$17 million (US) to a population of only 3 million adults. This extrapolates to a \$1.5 billion marketplace in a country the size of the United States (15). In July, 1997, McNeil Consumer Products Co. acquired the exclusive North American marketing rights to the stanol ester from Raisio (16). Forbes Medi-Tech, a bio-technology company in Vancouver, B.C., has also developed a cholesterol-lowering food additive and a cholesterol lowering drug from tall oil-derived plant sterols. The company projects the markets for the food additive and the drug to be \$4 Billion and \$6+ Billion (US\$). This technology was recently licensed by Novartis Nutrition for use in a wide range of nutritional products (17).

**Amaizing Oil Commercialization.** In July 1997, Monsanto purchased an exclusive license to develop corn fiber oil into a variety of products. A CRADA has been developed between Monsanto and ARS to commercialize "Amaizing Oil".

### **Zeagen Corn Fiber Gum**

Hemicellulose from corn fiber has been studied extensively (18) and it has been proposed as a useful food ingredient and industrial product because of its film forming, thickening, emulsifying, and stabilizing properties. Despite these attractive properties and the many documented efforts (19-23) to prepare a useful corn fiber hemicellulose (or "gum"), no commercial product currently exists. The reasons for the lack of success are somewhat unclear, but in many cases previous manufacturing processes did not yield an acceptable product (presence of undesirable corn flavor or color, etc.) at an acceptable manufacturing cost. In research led by Dr. Landis Doner of our group, we have now developed and filed a patent on several new processes (24,25) for the production of an off-white, highly soluble, bland tasting hemicellulose product we refer to as Zeagen corn fiber gum. The basic process involves alkaline extraction (using NaOH and/or Ca(OH)<sub>2</sub>) of de-starched fiber with a novel treatment with alkaline hydrogen peroxide (26,27). Experimental conditions can be varied to provide Zeagen with properties tailored to fit specific applications such as that shown below:

<b>Zeagen Property</b>	<b>Approx. Range of Values<sup>1</sup></b>		
Yield <sup>2</sup>	20 - 40%		
M <sub>w</sub> <sup>3</sup>	2.7 - 4.0 X 10 <sup>5</sup>		
WI <sup>4</sup>	38-50		
Viscosity <sup>5</sup>	50-60 cp		
Sugar Composition	Arabinose:	37 - 41%	Xylose: 48 - 50%
	Galactose:	5- 9%	Glucuronic Acid: 4-5%
	Glucose:	0-1%	

<sup>1</sup> Original Data Taken From (25). <sup>2</sup> Percent of Starting Weight of Corn Fiber, Dry Weight Basis.

<sup>3</sup> Weight Average Molecular Weight. <sup>4</sup> Whiteness Index; Standard White Tile = 83.2 (Hunter)

<sup>5</sup> Approximate Viscosity of a 5% Aqueous Solution At 25°C

**Zeagen Markets-** The potential markets for Zeagen are currently being studied. A likely application would be as a “home-grown” replacement for imported gum Arabic which commands an annual market of \$ 50 - 100 Million. Other food applications could surpass this level, and penetration of the 4 billion pound natural adhesives market could quickly utilize significant quantities of the estimated 3 billion pounds of Zeagen potentially available (assuming all available fiber was processed to yield Zeagen).

**Zeagen Commercialization** - An active CRADA between ARS and the National Starch and Chemical Company was initiated in 1997 to investigate the commercial development of corn fiber gum.

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