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Survey of US fuel ethanol plants

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ABSTRACT

The ethanol industry is growing in response to increased consumer demands for fuel as well as the renewable fuel standard. Corn ethanol processing creates the following products: 1/3 ethanol, 1/3 distillers grains, and 1/3 carbon dioxide. As the production of ethanol increases so does the generation of its coproducts, and viable uses continually need to be developed. A survey was mailed to operational US ethanol plants to determine current practices. It inquired about processes, equipment used, end products, and desired future directions for coproducts. Results indicated that approximately one-third of plant managers surveyed expressed a willingness to alter current drying time and temperature if it could result in a higher quality coproduct. Other managers indicated hesitation, based on lack of economic incentives, potential cost and return, and capital required. Respondents also reported the desire to use their coproducts in some of the following products: fuels, extrusion, pellets, plastics, and human food applications. These results provide a snapshot of the industry, and indicate that operational changes to the current production of DDGS must be based upon the potential for positive economic returns.

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1. Introduction

The increased demand for ethanol as a fuel source has amplified the need to find valuable uses for coproducts of the process. Thus, ethanol processing and its co-derivatives are currently the source of many research investigations. At the beginning of 2008, the United States expected to produce approximately 7.2 billion gallons of fuel ethanol utilizing 134 manufacturing plants. Currently, another 77 plants are under construction or expansion, which will be able to produce an additional 6.2 billion gallons of ethanol. When all plants are operating, a total of 211 plants will produce 13.4 billion gallons of ethanol annually (RFA, 2008).

Currently, coproducts such as distillers dried grains (DDG) and distillers dried grains with solubles (DDGS) are predominately used to provide nutritional value to the diets of livestock. DDG is a good source of crude fiber (13%) and protein (27–30%), but is low in total carbohydrate (46%) (Miron et al., 2001; Al-Suwaiegh et al., 2002; Davis et al., 1980). The nutritional content of DDGS, however, can vary more, containing 5–11% crude fiber, 27–34% protein, 5–6% starch, and 39–62% carbohydrates most of which is neutral detergent fiber (UMN, 2007; Belyea et al., 2004; Spiehs et al., 2002; NRC, 1998, 1982). The high nutrient (especially protein and energy) content allows these coproducts to be an excellent feed for animal diets. It also appears that ethanol coproducts may be viable ingredients for human foods (Rosentrater and Krishnan, 2006; Saunders et al., 2008).

The purpose of this study was to survey US ethanol plant managers about current production practices. The survey was used to acquire information about processes, equipment used, end products, and desired future directions for their coproducts. Responses and suggestions offer a glimpse of current industry needs.

2. Methods

A contact list was obtained through the Renewable Fuels Association website, which is freely accessible to the public (RFA, 2008). At the time of this study (early 2007), 111 ethanol biorefineries were available and operating at full capacity. Of those, 94 were included in the survey, while the remaining 17 plants were excluded from the survey because those plants' primary feedstock was not corn (i.e. barley, cheese whey, brewery waste, or sugars). An additional 75 plants under construction and 8 plants under expansion were also excluded from this survey as construction precluded coproduct production.

Four main categories in the survey contained 15 questions: processing issues, potential food applications, future research, and nutritional information. The self-administered survey was delivered through the US Postal Service and was designed to take no more than 5–10 min to complete. Returned surveys contained no identifying information unless the respondent voluntarily enclosed plant coproduct nutrition information. Respondents were also offered the opportunity to receive a final copy of this paper upon

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completion if desired, therefore voluntarily provided name, address, and/or email address as contact information. Assigning numbers to surveys in the order returned maintained confidentiality (1–23). The survey was reviewed and approved by the South Dakota State University Human Subjects Committee. It was determined that this survey did not fall under the federal regulations for human subjects' research. The original cover letter and survey tool are located in Appendices A and B, respectively. The survey was mailed out (*n* = 94) in March of 2007 to ethanol biorefineries with a stamped, return envelope provided to facilitate participation. All responses identified were kept confidential, and only used for the purpose of data analysis. Data was summarized using Microsoft Excel (v.2003) to calculate mean values. To facilitate data analysis, a value of 1 or 0 was assigned to responses for questions which required a "yes" or "no", respectively.

3. Results and discussion

Data analysis was completed on a question-by-question basis, as some returned surveys were missing data (i.e. not all surveys were completely filled out). No follow-up surveys were sent; therefore 23 out of 94 surveys were returned resulting in a response rate of 24.5%. Response rates of 30% from mail surveys are often considered "satisfactory" (Cooper and Schindler, 2003).

3.1. Processing Issues

3.1.1. Quantity generated (n = 23/23 responses)

A wide variety of ethanol plants were surveyed, thus resulting in a range of coproduct production rates. The minimum and maximum amounts reported were 9200 and 390,000 tons per year, respectively. The average for the survey data was 131,205 tons per year, while the median value was 74,000 tons per year; 52.2% of respondents indicated coproduct production less than 99,999 tons per year, 26.1% indicated between 100,000 and 199,999 tons per year, and 21.7% indicated greater than 200,000 tons per year. Coproduct generation values can indicate ethanol plant size and production capacities.

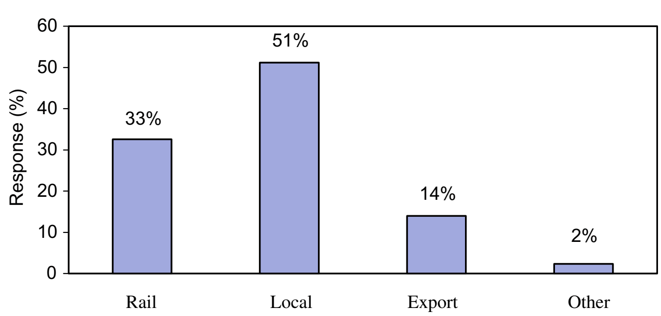

Fig. 1. Coproduct destination and transportation options currently used in industry (*n* = 23/23 responses). Note that rail denotes transportation for domestic DDGS use, whereas export denotes international shipment.

3.1.2. Coproduct destination (n = 23/23 responses)

Fig. 1 shows the distribution of destination and transportation method for coproducts among the following categories: ship by rail (for domestic use), export (i.e. international use), local animal feed, and other. Many survey respondents indicated more than one option for coproduct use after ethanol production at their particular plant. These data revealed that use for local animal feed (51%) was the most popular use of these coproducts, thereby benefiting local and surrounding communities. Golden LYK mineral blocks were a method identified in the "other" category, as a novel use for ethanol coproducts.

Rural economies are greatly benefiting from the ethanol industry in general, and coproducts in particular, as responses showed that many local farmers utilize this feed material. But an increasing amount of coproducts are being transported greater distances for final use (Rosentrater, 2007).

3.1.3. Typical deviations in chemical and physical characteristics (n = 23/23 responses)

Plant managers then identified various chemical and physical irregularities found in their coproducts. This information will allow researchers to classify areas that are increasingly problematic, and can be used to guide future research, that can ultimately benefit production practices. Fig. 2 categorizes the various deviations among US plants. The majority of respondents (51%) indicated that little variation was typically found in their coproducts. Other reported variations included color, burned coproducts, size of coproducts, quantity produced, soluble (i.e. CDS, or syrup) concentration, protein, and moisture. Less common deviations identified in the "other" category indicated were oil content and sulfur levels.

The identification of coproduct deviations was valuable, as these can be considered current weaknesses of the industry, or at least areas that could benefit from improvement. The need for uniformity in coproducts is great, as it impacts potential sales (Rosentrater and Krishnan, 2006). This is especially important when pursing value-added uses for coproducts, as well as using their use in animal feeds.

3.1.4. Dryer type (n = 23/23 responses)

One particular element that can greatly impact coproduct quality is the drying process. Fig. 3 shows the distribution of dryer types. An overwhelming 87.5% of ethanol plants surveyed utilized

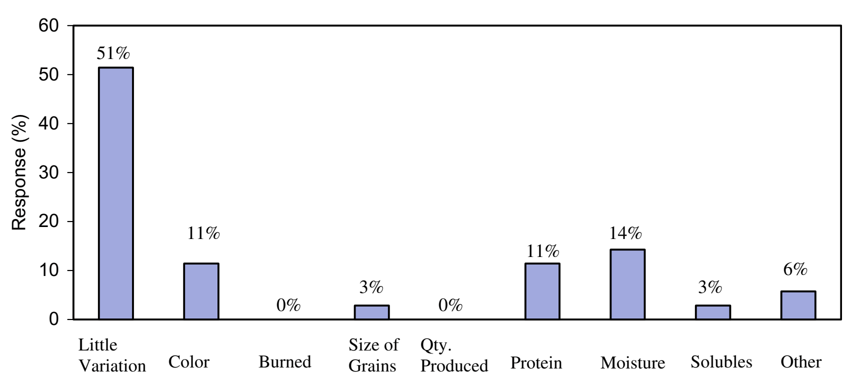

Fig. 2. Typical variations noted in coproducts (*n* = 23/23 responses).