Innovative Novel Technologies in Feed Processing

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Introduction

The challenge facing both animal agriculture and the feed industry will be the production of safe high quality meat, milk, and eggs with less quantities of traditional cereal grains and plant protein sources. The world population is expected to be 9 billion people by 2050. This will put more demand on feed ingredients to be used for human food that have traditionally been used for animal feed. The added demand will require more efficient use of the limited agricultural resources available for animal feed production worldwide. In addition to limited ingredient availability, consumers worldwide are demanding greater traceability of their food from farm-to-fork, which also adds to the costs of producing feed and animals. The feed industry will need to adapt to the use of non-traditional energy and protein sources, which may include significant inclusion levels of by-products from the food industry. However, the challenges with using more by-products include greater variation in quality and nutrient content, higher risks of mycotoxins, as well as traceability of the by-products from its original sources. Added to the challenge of limited ingredients are older feed mills that do not have flexibility to handle a wide variety of ingredients.

There have been changes in feed mills over the last 100 years; however, basic feed manufacturing processes of grinding, batching/dosing, mixing, and pelleting have withstood the test of time. Therefore, equipment manufacturers and feed manufacturing operations are continuously looking for new technology that can enhance the quality of the finished feed and the manufacturing process. The most common feed mill design is the pre-grind system, which was intended to grind one or two cereal grains but not soft ingredients. The next generation of feed mills will need to be post-batch grind systems that weigh the major ingredients, grind them, and then add the minerals and vitamins to the mixer.

While changes in the layout of facilities and improvements in equipment design will continue to improve the efficiency of the manufacturing process, the greatest opportunity for improvement may be in the area of precision animal feeding. Pomar et al. (2012) pointed out the essential elements for precision feeding included 1) evaluating the nutritional potential of feed ingredients, 2) precise determination of nutrient requirements, 3) formulating balanced diets that limit the amount of excess nutrients, and 4) the concomitant adjustment of nutrient supply to match the

requirements of the animals fed. Ingredients will need to be separated by nutrient content, while feeds will need to be blended onto the delivery truck based on animal genetics, age, gender, and stage of production. Technology will need to address the increased variation and intricacy of ingredient addition, and the feed industry will need to adopt feed manufacturing processes and systems similar to those currently being employed in crop production. Feed mills will thus need more ingredient and finished feed bin space, batch formulas will need to be adjusted for ingredient composition, and load-out conveyors with blending capacity will need to be added (Stark and Jones, 2015). While technology in other industries has developed at a record pace worldwide, its implementation in feed mills has been limited possibly due to the low profit margins in both animal agriculture and feed manufacturing. This paper will discuss innovative novel technology that has the potential to improve the performance of poultry and livestock production.

NIR Technology

The use of near-infrared (NIR) technology in feed laboratories has been used for over 30 years, but recently feed mills have started to embrace the use of table top NIR technology that can be located in different process areas of the feed mill. Additional advantages of NIR technology include minimal sample prep, production line or on-line analysis, high precision, low sample cost, and no chemicals or waste (Eubanks, 2013). NIR technology has evolved from the need to grind and load sample cells to simply placing the product on a plate in the unit. The user interface has also improved with touch screen technology. Table top NIR technology currently ranges from basic machines that measure moisture, protein, and fat to models that can measure moisture, protein, fat, fiber, starch, and amino acids. While table top models can provide useful point-in-time analysis, the greatest potential is in the use of in-line technology that has the potential to revolutionize ingredient quality by quantifying the moisture, protein, fiber, mineral, and fat content of ingredients as they pass across in-line probes (Stark, 2013). The ability to continuously monitor the nutrient content of ingredients going into bins is the first step in precision feed formulation. While understanding the proximate nutrient composition of received ingredients is important, the economic advantages in diet formulation are based on the company's ability to estimate energy (ME or NE) and amino acid composition of ingredients. The application of in-line NIR technology has the ability to revolutionize how feed is manufactured worldwide. Image using NIR technology to monitor particle size during the grinding process and make adjustments in hammermill tip speed through the use of a VFD or adjusting the moisture content of feed prior to leaving the mixer to provide a consistent moisture content to the pellet press. Finally, the moisture content of finish feed could be measured after pellet cooling and cooler residence time or fan speeds adjusted to meet the quality specifications.

While NIR technology is an exciting technology, feed companies must recognize that the NIR units are only as good as the calibrations used to predict nutrient content and the wet chemistry analysis. Companies must be willing to invest in both time and resources required to maintain robust calibration. New network-based software solutions allow an expert to precisely configure, manage and monitor NIR instruments from a remote location, which reduces the need for a NIR specialist at the facility (Tollecback and Mills, 2009).

Batching Technology

The number of ingredients used in feed formulation has significantly increased with the growth of the feed additive industry. The number of synthetic amino acids added to diets has increased as nutritionists increase the precision in formulation for animals based on genetics, sex, age, and health status. Added to the increase in synthetic amino acids, there has also been an increase in enzymes and probiotics. Feed additive suppliers have also been concentrating the enzyme, vitamin, and trace mineral premixes to lower the inclusion rate. The increase in the number and decrease in their inclusion rate has created challenges for automated batching systems. Older batching and weighing systems may not be capable of weighing ingredients to within upper and lower specification limits (1-2%) of the required quantities. For example, a requirement of 1.5 kg per batch would have a specification of +/- 0.015 kg or 15 g. Unfortunately, precision formulation pushes the limits of tolerance levels in manufacturing due to the fact that not adding enough of an ingredient will result in poor animal performance, whereas the over addition of ingredients will result in ingredient shrink and nutrient excretion (Stark, 2014). Micro-systems that were designed with a 0.05 kg accuracy are not precise enough to add 1.0 kg of an enzyme and 1.25 kg of a vitamin premix per batch of feed. Feed mills will need more bins for micro-ingredients and a system designed with a 0.01 kg resolution and variable frequency drive (VFD) controllers to increase the accuracy of ingredient additions during the batching process. However, batching accuracy is often dictated by the size of the screw conveyors and ingredient density and flow ability. Premix manufacturers and equipment manufacturers will need to work closer in the future to not only ensure the product is added accurately, but that it will also flow through the micro-bins.

Automation Technology

The automation of the feed manufacturing process has advanced significantly in the last 30 years from large push button panels to green screen monitors in a control room to now controlling and troubleshooting equipment from a smart phone any place in the world. In addition to the computer controlling the equipment, there is significantly more data captured during the manufacturing process. The challenge is how to deal with the data and convert it into useful information that can be used to improve the process (Koeleman, 2014). Guyer (2013) stated, "Most feed companies have made great investments in financial packages and formulation tools, but without understanding how to unlock their full value and potential, these tools may bring a false sense of security." Companies that provide automation have begun to incorporate more reporting and statistical process control features into the automation package. Automation packages now use statistical process control to monitor everything from how long it takes a truck to unload to the batching accuracy of ingredients. Statistical process control can now be used to improve the precision of the batching process. Managers can review both real-time and historical data and make changes in parameter settings and equipment set-up that can improve the accuracy of each batch of feed.

The next generation of automation systems will not only control equipment and collect data, but will be integrated into the company's animal food safety systems. Consumers around the world are not only demanding more meat, but that the meat is produced in a safe, sustainable, and responsible production system. Next generation automation systems will track ingredients from farm-to-fork. Automation systems will track ingredients from the time of purchase, during receiving, processing, and delivery to the animal producer. Integrated Radio-Frequency Identification (RFID) tags are being added to both ingredient and finished feed trucks. The information associated with the delivery of an ingredient can then be automatically captured as the trucks enter the receiving area. The RFID can relay the purchase order, supplier, transportation company, and driver information, as well as inform the operator of the sampling requirements and quality control procedures that must be performed based on the ingredient supplier history, and regulatory requirements. The quality data captured on an individual load can then be tied back to the company's purchasing and accounting systems. Facilities can also use the software to track the ingredient throughout the facility as it moves from the storage bin or warehouse to processing equipment or premix area and then to finished feed load-out bins or warehouse. While this is easier with bagged ingredients than bulk, the concept is still the same. Finally, once the feed is ready for delivery, RFID can be used to check what was hauled on the delivery truck prior to loading, automatically load the compartments of the truck and track the delivery of the feed to a bin on the farm based on RFID technology installed on each compartment of the truck, the end of the delivery boom, and each farm bin.

The key to making all of the technology work seamlessly is data exchange between different software packages. For example, companies are now monitoring the nutrient content of ingredients with in-line NIR technology, sending that information to the feed formulation software to make adjustments in the formulation, and then adjusting the batching software with minimal human interface. The adoption of new technology in the feed industry will occur at a faster pace as software companies develop improved data exchanges between the processing software and business management software.

Conclusion

The global feed industry is at its infancy of incorporating processing technology into the feed manufacturing process. In the future, the nutrient content and value of ingredients will be determined as the ingredients are being unloaded from the truck, diet formulas will be adjusted based on the nutrient content of the ingredients that will be used for the production run, and feed will be loaded onto trucks using in-cab cameras and on-board computers. The new technology will allow feed manufacturers to incorporate higher percentages of by-products into feed, as traditional animal feed ingredients are diverted to human food. The ability to provide traceability from farm-to-fork will also provide a greater confidence to consumers. Innovative novel technologies will allow feed manufacturers to focus on developing programs to efficiently produce a high quality feed for the production of meat, milk, and eggs. In order to meet future

demands of food safety and feeding 9 billion people by 2050, the feed industry must employ precision feed manufacturing. This will require an integrated coordination of each step of the manufacturing process, from purchase of the ingredients to final feed delivery and consumption.

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