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Food Safety Series—Traceability in the Bulk Grain Supply Chain

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Food Safety Series—Traceability in the Bulk Grain Supply Chain

Abstract

Consumer experiences with food safety issues combined with a growing demand for high-quality food and feed products have increased interest in systems to aid in food traceability efforts. Implementation of a traceability system in the bulk grain supply chain is a complex task. Food safety concerns are increasing in the United States as bulk commodities are commingled for domestic and export purposes without traceability systems and quality management controls. Recent food safety events--aflatoxin in grains, salmonella in spinach and tomatoes, and melamine in feed and food--caused illness or death in humans and animals. The lack of quality controls and traceability systems played a major role in the slow identification of the suspect products. Food safety and traceability laws exist in several countries, but traceability is important for several reasons other than just a legal obligation. These reasons include efficient response to food security threats, documenting the chain of custody, documenting production practices, meeting regulatory compliance, and analyzing logistics and production costs.

Keywords

Food safety, bulk grain, traceability, identity-preserved grains, ip, milk supply chain

Disciplines

Agriculture | Bioresource and Agricultural Engineering | Operations and Supply Chain Management

Comments

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Implementation of a traceability system in the bulk grain supply chain is a complex task. Food safety concerns are increasing in the United States as bulk commodities are commingled for domestic and export purposes without traceability systems and quality management controls. Recent food safety events— aflatoxin in grains, salmonella in spinach and tomatoes, and melamine in feed and food—caused illness or death in humans and animals. The lack of quality controls and traceability systems played a major role in the slow identification of the suspect products. Food safety and traceability laws exist in several countries, but traceability is important for several reasons other than just a legal obligation. These reasons include efficient response to food security threats, documenting the chain of custody, documenting production practices, meeting regulatory compliance, and analyzing logistics and production costs.

The U.S. Bioterrorism Preparedness and Response Act of 2002 (the Bioterrorism Act) requires all companies involved in the food and feed industry to self-register with the Food and Drug Administration and to maintain records and information for food traceability purposes. According to the Bioterrorism Act, in the event of a food-related emergency, an affected company should be able to produce records on the product, the related suppliers, and the customers based on one step up and down in the supply chain within a 24-hour time frame. Ultimately, food traceability is the responsibility of all the actors in the supply chain, so effective supply chain traceability can only be achieved with a combination of inter-

nal traceability and chain traceability. This article summarizes recent efforts at Iowa State University to understand and improve bulk material traceability.

Optimization of internal and chain traceability

Different lot-activities take place as grain moves through the supply chain from the farm to the consumer (fig. 1). At the grain elevator, grain lots (inbound deliveries) are commingled to meet buyer specifications, and lot identity is not maintained. As a result, an outbound shipment to a customer can contain grain from many sources (fig. 2). In a food-related emergency, it would be almost impossible to trace the problem source and to track other affected lots. This problem can be mitigated by an efficient internal record-keeping system that documents all grain activities, including movement, aggregation, segregation, transformation, and destruction. As a part of our traceability research, a relational database management system has been developed for internal traceability at a grain elevator. This system stores all the information related to grain lots and can be queried to retrieve information related to incoming and outgoing lots. This system can be used to trace back the source of a given lot and track forward to find information related to the shipped lots. In addition, an optimization model has been developed for minimizing the traceability effort based on the quantity that would be recalled in the event of a food safety concern. A simulation-based optimization technique is being developed to identify the critical points in the grain supply chain and propose changes in the storage and handling practices, with the goal of maximizing the profit from blending while minimizing the food safety risks.

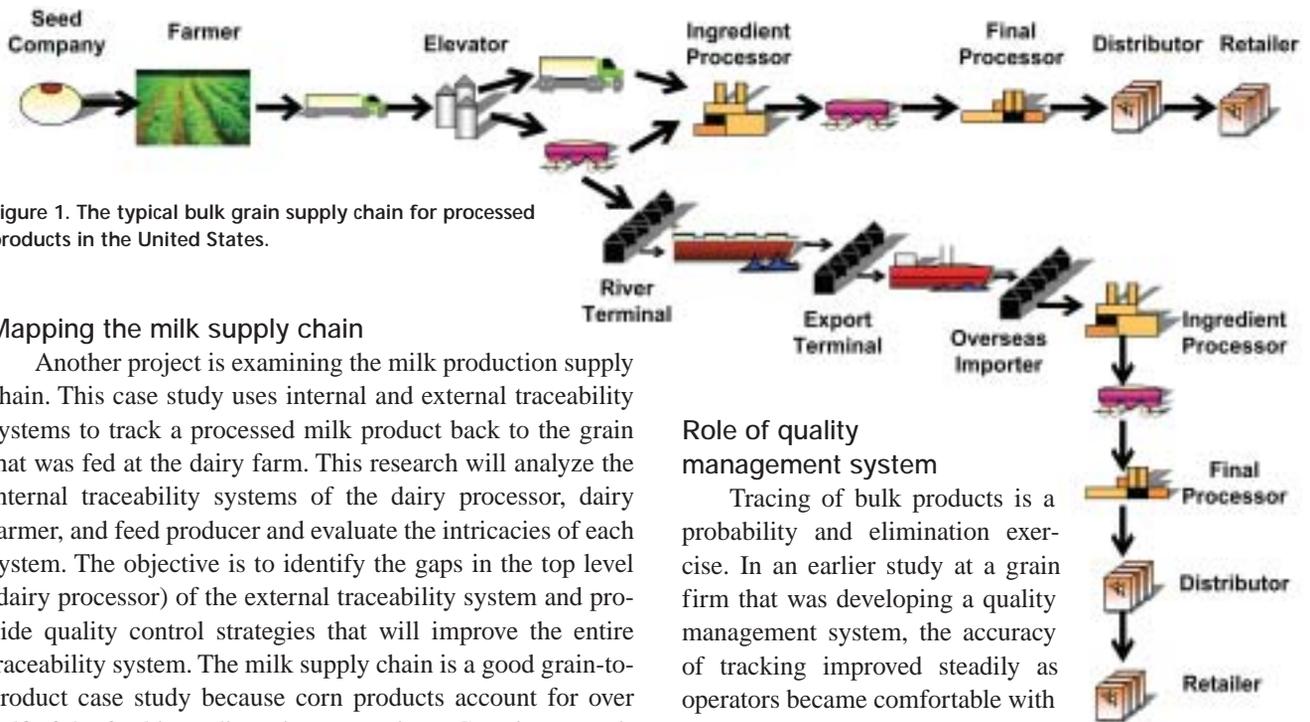


Figure 1. The typical bulk grain supply chain for processed products in the United States.

Mapping the milk supply chain

Another project is examining the milk production supply chain. This case study uses internal and external traceability systems to track a processed milk product back to the grain that was fed at the dairy farm. This research will analyze the internal traceability systems of the dairy processor, dairy farmer, and feed producer and evaluate the intricacies of each system. The objective is to identify the gaps in the top level (dairy processor) of the external traceability system and provide quality control strategies that will improve the entire traceability system. The milk supply chain is a good grain-to-product case study because corn products account for over half of the feed ingredients in most rations. Corn is susceptible to aflatoxin, which can be passed from the feed to milk in lactating animals. In addition, distillers dried grains and solubles (DDGS) are now being used as an ingredient in dairy cattle feed. If a contaminated lot of corn is processed for ethanol, the resulting DDGS will contain approximately three times the original amount of aflatoxin, or other problem substance.

Role of quality management system

Tracing of bulk products is a probability and elimination exercise. In an earlier study at a grain firm that was developing a quality management system, the accuracy of tracking improved steadily as operators became comfortable with basic recording procedures for handling operations. Accuracy is measured by the ratio of potentially suspect product to the amount of contaminated product, or the traceability index. In over 50 trials, the ratio ranged from 1000 down to 10. Perfect traceability would be 1, which is unlikely to be achieved. The goal is to minimize the possibilities.

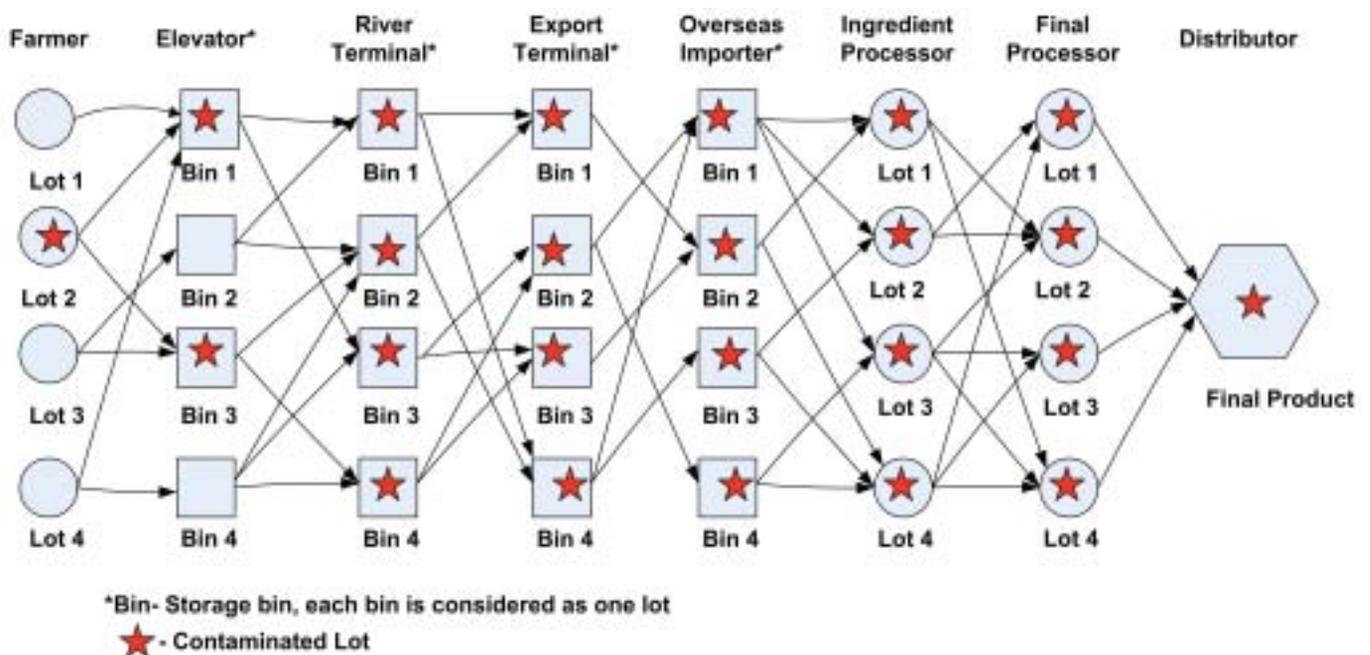


Figure 2. A typical grain lot blending scenario, showing how one contaminated lot can rapidly contaminate other lots. Depending on the severity of contamination, the consequences can be very harmful both for consumers (food safety) and producers (cost of recalls).

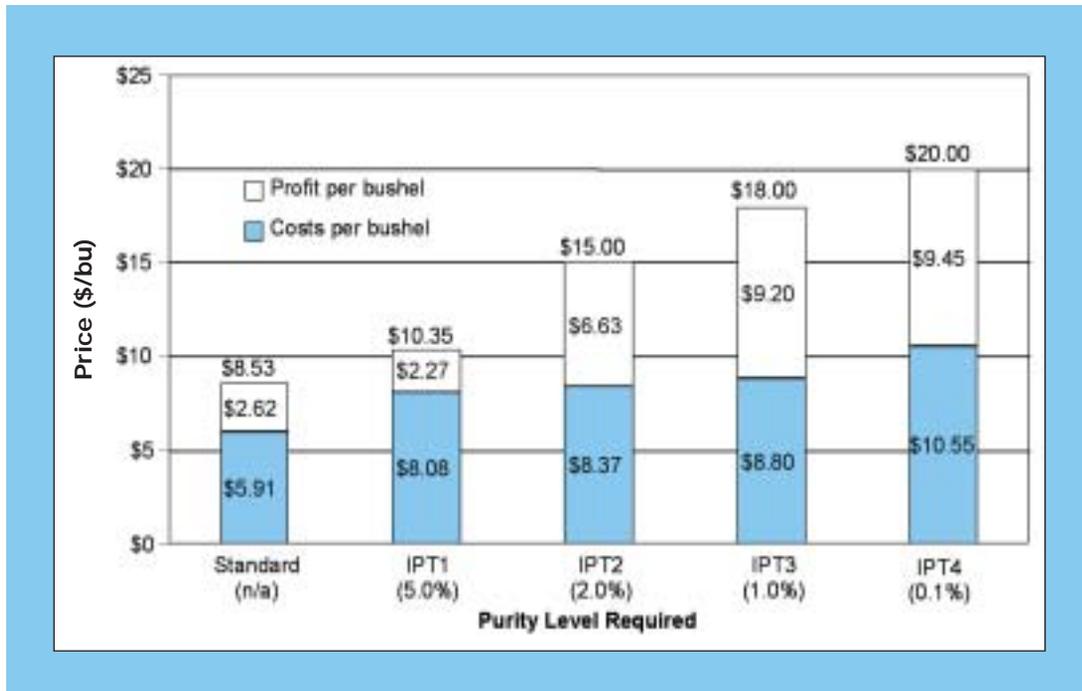


Figure 3. Example results of cost-benefit analysis for purity tracking.

Cost-benefit analysis

Identity-preserved (IP) grains are produced with a specific end use in mind, such as for food, feed, or pharmaceutical use. Likewise, some grains need to be isolated for particular end uses, such as for buyers sensitive to biotechnology. These IP grains need to be segregated in order to preserve their identity. Traceability systems play a vital role in maintaining an efficient segregation system. It is also important to determine the profitability associated with segregation of grain for different purity levels. A cost-benefit analysis of an on-farm traceability system was conducted to determine if a particular IP crop at a specific purity level would be profitable to grow. The price per bushel increased as the purity level requirements increased (fig. 3). Farm management practices have a tremendous impact on expenses and on the ability to meet specific purity levels. A detailed cost and operational analysis protocol was designed to obtain meaningful results in cost-benefit analysis.

Decision making and risk analysis

The implementation of traceability systems often occurs through the use of quality management systems or International Organization of Standards (ISO) processes. This project will quantify factors involved with employee decisions concerning quality within the country elevator environment, identify needs for improved standard operating procedures, and identify needs for educational intervention. The risk analysis examines selected operations that affect grain quality, from seed purchase to end user delivery, using fault tree analysis. Fault tree analysis identifies contributing

factors in complex systems, illustrates interrelationships of the causes of specified events, and quantifies probabilities of occurrence for each pathway of events. Those with the highest probabilities for negative consequences are targeted for educational intervention or other countermeasures. Although each component varies in focus, the underlying concept is to provide data to guide educational efforts in traceability for producers, processors, handlers, and other actors in the agricultural supply chain.

Final thoughts

Various traceability issues in the bulk grain supply chain are being addressed by our research group. The main goal of the effort is to develop a methodology for implementation, quantification, and optimization of traceability systems in the bulk grain supply chain in order to improve food safety. From our results so far, improvement of traceability with supporting quality management systems has significant potential to increase profits through operational efficiency.

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