Uninterrupted traceability in bulk grain flow and trade: Possibilities and limitations of Radio Frequency Identification

Rodarte A\textsuperscript{1}, Steinmeier U\textsuperscript{1}, Deimel M\textsuperscript{2}, von Hoersten D\textsuperscript{1}, Theuvsen L\textsuperscript{2}, and Luecke W\textsuperscript{1}.

\textsuperscript{1}University of Goettingen, Department of Crop Science, Section Agricultural Engineering, Gutenbergstrasse 33, 37075 Goettingen, Germany.
\textsuperscript{2}University of Goettingen, Department of Agricultural Economics and Rural Development, Platz der Goettinger Sieben 5, 37073 Goettingen, Germany.

Problem Statement and Introduction

Food legislation requirements on traceability and the pressing issues regarding quality and safety issues of foods and feed impose technical and restructuring challenges for individual stakeholders along the food supply chain. Imminent market adjustments and increased organizational efforts in information transfer, especially for small and medium-sized businesses, had been foreseen even before the Regulation (EC) No 178/2002 came into force in 2005 (LZ Net, 2003).

Although the discussions, from the legal perspective, in regard to the ultimately manageable requirements of the Article 18 faded down (HOLLMANN-HESPOS und THEUVEN, 2007), the topic “traceability” has gained again considerable relevancy. For agricultural commodities like grains, in particular, the aspects of batch tracing, documentation and information flow along the food supply chain have become recent topics of discussion. Determinant drivers are the increased globalization of commodity flows in association to ever bigger terminals. This affects, for instance, the compliance of the “zero tolerance” by European imports of non-permitted genetically modified organisms (GMO). This concerns not only soybeans from the country of origin like the USA, but also the imported grain that are transported in the same vessel. Even the most minimal quantities of GMO containing residues of previous charges are by now able to be identified by the extremely sensible detection methods (MENRAD et al., 2003) and result in the rejection of complete shipments.

Along with the internationalization of trade flows, the modifications in the cultivation processes at the primary production level pose new driving forces of gapless documentation and traceability. This is due to the economically caused constrictions on crop rotation in grain cultivation, as well as methods for the reduced soil preparation and extension of corn cultivation area, that can foster the accumulation of toxin building pathogens, especially fungi of the Fusarium genus (OBST et al., 2000). Due to their chemical stability, mycotoxins represent a problem along the whole supply chain of both foods and feeds (MATTHÄUS et al.,
2004; Pawelzik and Theuven, 2008). With this background, cereal grain trade and milling firms have started for a few years now to perceive mycotoxins as an increasing quality risk. The methods used currently for the tracing of grain overlook the deficits when it comes to the particularities of trading commodities stored and handled in bulk. From the harvest onwards, cereal grains are transported loose in bulk and there is a frequent mixing of different batches along the operations of storage and handling (Steinmeier et al, 2009). There is the need for optimization of the current systems of traceability: documentation, setting aside of samples of individual batches, and isotopic analysis. These needs can be met with the application of Radio Frequency Identification (RFID) technology.

**Objectives**

To evaluate the presently used tools for the traceability of bulk grain and discuss the role of RFID for the thorough information control along the cereal grain food supply chain.

To develop a protocol for a RFID based traceability system, which may close the traceability gaps from primary production of cereals to milling.

**Procedures**

The procedure used was a literature research and investigation of traceability practices in the trade of bulk grain. Additionally a technical approach is being developed in the framework of a project to study the feasibility of applying RFID technology in the grain bulk from the point of harvest to the milling facility. As mentioned above, supply chain operations from harvest to processing of grain include one or several activities of storage and transport, and, therefore, the frequent mixing of different batches.

Within the joint project “Quality-related plant production under modified basic-conditions: mycotoxins in the context of production, quality and processing“, the Section Agricultural Engineering of the University of Goettingen has performed experimental trials for the practical implementation of Radio Frequency Identification (RFID) to ensure traceability of grain. The concept is to introduce an encapsulated radio frequency (RF) transponder, the so-called corn dummy, into the bulk grain at predetermined points in the supply chain. This transponder can be up-loaded with specific information of the grain producer and corresponding batch.
Results

The presently used traceability systems (e.g. paper documentation and retained sample of every batch, or the use of isotopic analysis) have limitations, particularly the determination of the proportion of batch mixtures (AGROISOLAB, 2010). A better depiction of the degree of mixing can be obtained using a tracer-based system (STEINMEIER et al., 2009). An encapsulated RFID transponder was developed (BEPLATE-HAARSTRICH, 2007) and the mixing behaviour of the corn dummy (Figure 1 and 2) in bulk grain has been analyzed in a model silo. Pilot experiments have shown a low failure rate of allocation of the corn dummies to a certain batch. However, some issues still remain to be resolved like: how to introduce the encapsulated RF tag into the grain (through a device in the combine harvester) at the harvesting stage, how efficient the removal process can be made, and how safe and precise the traceability system is.

Figures 1 and 2. Corn dummies and mic3® tags: 64 byte read only; size: 1.6 x 1.0 x 0.5 mm; read distance: up to 5 mm. Beplate-Haarstrich, 2007.

After the different storage and handling operations, the RF tracer must be consequently removed in the milling facility before processing into flour. At an experimental scale, a
A separation unit with a metal detector was developed and showed a high corn dummy removal rate.

Conclusions

With means of miniaturized RFID technology, it is possible to label bulk goods like cereal grains. The data of point of origin, even of different batches, can be traced back and is carried in the bulk grain, without need of further documentation. For this technical approach it is however necessary to adapt the RFID transponder to the particular characteristics of the commodities to be marked. The corn dummy design is of great relevance and it needs to reflect the mixing behavior of the grain.

Further research activities include the development of the tracer dosing unit for the combine harvester and experiments on different grain handling and conveying methods (e.g. along conveyor belt). Ultimately, the technical experiments must be up-scaled to establish recommendations for the practical implementation of the developed RFID-based traceability system to a real life level.

The application of RFID technology for bulk grain must be still improved to overcome the difficulties of limited reading range and be standardized to established practices in the industry, and therefore become a feasible option in international grain trade.

Summarizing, existing traceability systems for bulk grain must be adapted to the demands of increasing volumes of commodity flows and the needs for and efficient reliable differentiation of grain shipments of diverse origins and qualities. It is expected therefore, that a functional traceability system can make a decisive contribution in the case of recalls of a food or feed product in an efficient matter, and with a low impact damage of image and company budget.

References


Acknowledgements

This research has being funded within the framework of Lower Saxony’s second and third cooperative network of agriculture and nutritional science (Forschungsverbund Agrar- und Ernährungswissenschaften Niedersachsen, FAEN), managed by the Lower Saxony Ministry of Science and Culture. www.verbundprojekt3-faen.de; http://www.verbundprojekt2-faen.de/.