

# Blockchain Application for Halal Integrity: Exploratory Study

**Iwan Vanany and N.A. Nandya Shafira Pramesti**

Department of Industrial and Systems Engineering  
Institut Teknologi Sepuluh Nopember  
Sukolilo, Surabaya 6011, Indonesia  
[vanany@ie.its.ac.id](mailto:vanany@ie.its.ac.id), [shafiransp13@gmail.com](mailto:shafiransp13@gmail.com)

**Nur Aini Rakhmawati**

Department of Information System  
Institut Teknologi Sepuluh Nopember  
Sukolilo, Surabaya 6011, Indonesia  
[nur.aini@is.its.ac.id](mailto:nur.aini@is.its.ac.id)

**Jan Mei Soon**

University of Central Lancashire, Faculty of Health and Wellbeing  
International Institute of Nutritional Sciences and Applied Food Safety Studies  
Preston, United Kingdom  
[jmsoon@uclan.ac.uk](mailto:jmsoon@uclan.ac.uk)

## Abstract

Critical factors of the blockchain application are believed to be due to halal awareness from company leaders, the benefits obtained, and the ease of implementation. The purpose of this paper is to explore awareness of halal integrity, the perceived benefits, and the possible implementation of blockchain applications for halal integrity. Some critical factors of blockchain applications that are investigated are the awareness of halal integrity, the perceived benefits of halal integrity, and the priority implementation of halal integrity in the upstream and downstream supply chains. Two companies in the pharmaceutical and chicken slaughtering industry were used to understand their opinions on the three main questions of this study. The selected companies are companies that pay attention to blockchain applications as one of the important applications that can be used to increase their market by strengthening their halal integrity. The research method used to collect the responses from the key managerial personnel with experience and knowledge is online interviews. Through this research method, the understanding of blockchain applications for halal integrity in the pharmaceutical and food industry especially the slaughtering industry can be discovered.

## Keywords

Halal integrity, Blockchain, Exploratory study, Indonesia

## 1. Introduction

In recent years, the integrity of food and pharmaceutical products are becoming a major concern to food authorities, researchers, the food supply chain and consumers. Food integrity is a discipline that pays attention to how food products are sourced, procured, processed, and distributed from farming until end customers (Elliot, 2014). Similarly, the pharmaceutical industry also pays close attention to the integrity of pharmaceutical and health supplementary products. This issue is closely related to the supply chain and requires an integrated, multi-pronged approach in science, social science, information technology, and organisation management to ensure the integrity in

the supply chain. Managing food integrity is the responsibility of all actors in the supply chain and must be fully integrated and comply with an assurance system (Tan et al. 2017). Traceability, visibility, quality, and risk assessment concepts are needed to ensure the integrity of the supply chain (Aung and Chang, 2014). It is suggested that the term food integrity should be used to describe foods that are properly represented for exactly what they are (Manning and Soon, 2014). So, halal integrity would be again clearly presenting the details of the halal status of the product and assuring that the requirements for halal as stated are met. Halal integrity is a new issue that has emerged following the food and drug integrity. Ali and Suleiman (2018) believed that religious factors also influence the importance of the integration of halal food in addition to the safety, health, and quality of food. Soon et al. (2017) defined halal integrity as the assurance of safe (pure), quality (good) and free from mal-practice (lawful) food from farm to fork.

Halal industry is the fastest growing global business fueled by the growing Muslim population (Yusuf and Yajid, 2016). Farm and food manufacturers, food service providers, logistics and transportation, standards and food safety and quality certification bodies can potentially tap into the booming halal industry. The explosion of digital data known as big data coupled with the Internet of Things (IoT) are potential opportunities in halal trade. Data allow business operations to collect, analyze, measure, and make informed decision in their operations (Speranza, 2018). The assurance of halal integrity using information and digital data provides opportunity for blockchain technology (BC) in halal food supply chain. Blockchain is a promising technology that provides food supply chain stakeholders with secure, irreversible, and auditable list of records and as a result a database that can be interrogated. Blockchain is essentially a list of records which are linked using cryptography and distributed databases. Once a block is recorded, it is permanent and cannot be changed (Foth, 2017).

Previous studies regarding the application of blockchain technology for halal product in the supply chain are relatively few in line with the new application of blockchain technology in the practical business. Previous research is still dominated with review of literature, exploratory study for the possibility of blockchain application, and the conceptual frameworks in halal food. Rejeb (2018) proposed the conceptual framework for halal meat blockchain system. Katuk (2019) conducted a systematic review to identify and evaluate previous research in halal assurance using blockchain implementation. Rohmat et al. (2019) reviewed the traceability system and possibility of the blockchain application in halal food traceability system. Chandra et al. (2019) identified the challenges of the halal food industry using blockchain technology and redefined the existing systems to implement blockchain applications. Tieman et al. (2019) observed the potential role, key parameters, and communication requirements of halal blockchain based on Focus Group Discussion (FGD) and suggested that blockchain technology can be used to enhance halal transparency and integrity by distributed ledgers and smart contracts. A recent study proposed the implementation of blockchain platform to secure halal food integrity in Indonesia (Vanany et al. 2020). This was one of the few studies that took business and halal authority views into consideration. Such frameworks, architecture, and data structure of halal integration using blockchain technology that are relevant and specific to the food business and regulatory requirements are still lacking.

This paper aims to explore three main issues in blockchain application for halal integrity: (i) the awareness of halal integrity; (ii) the perceived benefits and opportunities; and (iii) the possibility of implementing blockchain application. The focus of this study is on halal products in pharmaceutical and food industry. This paper is structured as follows. Section 2 presents the research design, followed by results and two specific case studies (a) pharmaceutical and (b) food industry. Section 4 discusses the implementation of blockchain and the final section presents the conclusion including limitations, research implications and future research.

## 2. Methods

Exploratory study was employed in this study to investigate the main issues of blockchain application for halal integrity. Both the halal pharmaceutical and food industry were utilised as the unit of analysis in this study. The two case studies were used as both industries provide disparate analyses and diverse cross comparison to explore the research questions. A semi-structured interview guide was developed based on literature review (Katuk 2019, Rohmah et al. 2019, Chandra et al. 2019, Tieman et al. 2019). Representatives from the pharmaceutical and food industries were contacted and the study was explained to them prior to obtaining their informed consent. Semi-structured interviews with key managerial personnel with at least 5 years of work experience in halal system were conducted.

The duration of interviews were approximately 60 minutes, and the results were recorded automatically via Zoom. The recordings were viewed and transcribed verbatim and translated into English. The case study method was chosen to answer the main research questions due to the richness of the case data in small number cases (Eisenhardt, 1989). Semi-structured interviews and documentation is used in this research to ensure the validity and reliability of the study (Yin, 2017). How the conditions and research methods used in previous research in the field of halal operations in Indonesia are also elaborated (Vanany et al. 2019a, Vanany et al. 2019b).

The main set of sub-questions is identified as follows:

- Q1. Awareness of halal integrity: How important is halal certification for your company? Can you describe the halal certification your company has? Please describe if your main customers and suppliers are aware about halal integrity (upstream and downstream supply chain)? To what extent does your company refer to halal integrity in your business?
- Q2. The perceived benefits: In your opinion, what are the main benefits to the industry if your company implements blockchain for halal integrity (downstream and upstream supply chain)?
- Q3. Possibility/priority implementation of blockchain application for halal integrity. In your opinion, can application blockchain application for halal integrity be implemented in your company? How big is the impact if implemented?

### 3. Data Collection

Online interviews were conducted with managers from a pharmaceutical and food processing company (i.e., chicken slaughtering plant). The empirical findings are explained in detail in the following sections. The two cases of halal supply chains conducted in this research demonstrate different scale of industries, number of plant and employees, types of halal products, market, and source of raw materials. The details of company and interviewees profiles are described in Table 1.

Table 1. Company profile and interviewees information

Factor	Case 1	Case 2
<b>Company Profile</b>		
1. Type of Industry	Pharmaceutical industry – (pharmacy company)	Food industry – (chicken slaughtering company)
2. Scale of company	Large (Badan Pusat Statistik (BPS))	Large (Badan Pusat Statistik (BPS))
3. Number of plants and employees	1 pharmacy processing plant in Indonesia - 600 employees	2 processing plants – 500 employees
4. Main products	a food supplement in the form of a multivitamin tablet	chicken meat
5. Market	40% are local in Indonesia and 60% are exported	100% are distributed in Indonesia
6. Source of raw material	More than 70% come from overseas	100 % of raw materials from domestic
<b>Interviewee's information</b>		
1. Position of interviewee	Head of Supply Chain	Head of Quality Assurance and Control
2. Number of years in halal industry	More than 7 years	10 years
3. Education background	Master's degree	Bachelor's degree

#### 3.1 Case 1: Pharmaceutical Industry (Food Supplement and Multivitamin)

Case 1 of this research is a global company in the pharmaceutical industry that has a factory in Indonesia to produce products targeted to consumers' health. The main products are food supplements in the form of multivitamin tablets. Approximately 60% of the products are exported to 28 countries and 40% are distributed in Indonesia. The domestic markets are not only distributed to Java Island as the biggest market in Indonesia but also to Sumatera, Kalimantan,

Bali, and others. One specific product that is calcium supplement that helps maintain healthy bones and teeth in adults and pregnant women has become a product leader in Indonesia. More than 70% of the main raw materials are procured from overseas and 30% of the main materials used are domestic raw materials. More than 95% of case 1's suppliers are suppliers from other companies worldwide.

The awareness and concern for halal integrity is high. Most of their products have a halal certification issued by Indonesian Council of Ulama (MUI) which is the halal authority in Indonesia. Halal certification is necessary to keep customers' trust and to assure that their products are following the halal requirements and received halal assurance from MUI. The pharmaceutical company is inspected, and halal certificate is renewed every 2 years according to the rules of the MUI. Consumers also consider the importance of halal certification as formal evidence that the halal requirements of all aspects in the company have been met and certified by MUI. The main customers are also aware of the importance of meeting halal requirements throughout the chain i.e., from the sourcing of raw materials to product delivery, hence validating the need for halal integrity.

The company strongly refers to halal integrity so that case 1's products of customer health are guaranteed of their integrity starting from the raw materials, handling, and processing of products in accordance with the rules of halal requirements. The halal requirements of the raw materials and their ingredients are crucial and are verified by the procurement party before making a purchase. Directors, managers, and heads of production are the persons who are responsible for the halal requirements of their multivitamin products. Since the pharmaceutical company practices halal integrity throughout its supply chain, halal has become a key strategy in product marketing.

The pharmaceutical company believed that the benefits of halal integrity will be substantial and even more secured and assured with blockchain application. The perceived benefits may be due to the support of encrypted digital which assists in tracing and tracking halal certification across the supply chain. The existence of halal authenticity of the raw materials is what the company wants from its suppliers. Transparency from suppliers regarding the halal integrity of the raw materials used, processes and others is expected to exist between the company and the supplier. The traceability systems will be enhanced especially with suppliers and customers. Increasing integration with suppliers will also be expected with blockchain application.

### **3.2 Case 2: Chicken Slaughtering Industry (Chicken Meat Products)**

Case 2 of this research is a big company in chicken slaughtering industry that currently employs more than 500 employees. It has two plants located in East Java, Indonesia. The production capacity ranges from 6,000-8,000 units per day. The main products are chicken meat in the form of carcass, skinless, breast, boneless, and others. Nearly 100% of the products are distributed throughout Indonesia, to retailers and food services, such as fast-food outlets, restaurants, catering, hotels, and others. About 70% of the product is distributed to outside Java Island, while 30% are distributed locally. The main raw materials are broilers of which 95% are sourced from external chicken farms and 5% are produced from the company-owned farm. All products from the company have been certified as halal by MUI.

Company awareness of the need for halal integrity is high. Halal certification is important to guarantee consumers that their products are halal. Halal certificate is mandatory, and companies will always renew halal certificates in accordance with the applicable regulations.

Case 2's consumers such as restaurants, fast food outlets, hotels, and others, also consider halal certification as very important. Although case 2 reported that the company aims to renew halal certificates according to the national regulations, the company had faced challenges in marketing due to the expired validity period of the halal certification. Main customers from case 2 have end customers who consume the product and pay close attention to the halal logo before they buy and consume the product. Final consumers in Indonesia are dominated by people who adhere to the teachings of Islam. The integrity of halal food in the company is strictly maintained starting from the raw materials used, the process carried out, the tools and facilities used, and the distribution of finished products to consumers by referring to SJH (Halal Assurance System) / HAS 23000. Halal supervisor is the key person responsible for the halal integrity of their product. Halal is also one of the company's strategies in marketing its products to consumers.

In case 2, similarly, the perceived benefits of halal integrity will be substantial and secured with blockchain application. The existence of halal authenticity from the start of poultry farming until the delivery to consumers will

be easily achieved by applying blockchain technology. Transparency of every activity, including butchers and the equipment used that meets halal requirements, will be easily done with the blockchain application. Consumers can see the transparency of each process for the chicken product they buy with the blockchain application for halal integrity. Traceability from broilers received to finished products are sold and distributed to consumers will increase significantly when using blockchain technology. The existence of blockchain application for halal integrity is also believed to be able to achieve integration and support for the renewal of halal certificates.

#### 4. Results and Discussions

The findings from the two case studies are summarized in Table 2. The following are the discussion pertaining to the upstream and downstream perspectives of halal integrity, perceived benefits, and priority implementation from the halal integrity using blockchain application in the supply chains. Awareness of halal integrity from suppliers is more prominent in the pharmaceutical industry compared to the chicken slaughtering industry. Due to the complexity and length of the supply chain, it remains a challenge to determine the halal integrity of a variety of raw materials and ingredients in the pharmaceutical industry. In addition, the source of raw materials is dominated by foreign suppliers. Unlike the chicken slaughtering industry, the main raw materials are broilers obtained from domestic suppliers. However, food safety in the form of antibiotic residue content and antemortem examination (healthy, physically normal, free from disease, etc.) is a concern compared to its halal status.

The pharmaceutical industry prefers to implement blockchain application in the upstream network as the first phase of halal integrity assurance using the technology. Since choosing the upstream supply chain, the perceived benefits of halal integrity that are believed to be achieved with the blockchain supply chain are strengthening halal authenticity, transparency and trust, traceability system and integration with their suppliers in the pharmaceutical industry. Perceived benefits of halal integrity using blockchain application in chicken slaughtering industry that are believed to be achieved are traceability system and integration with suppliers. If companies in pharmaceutical and chicken slaughtering industry have existing traceability system in place, the integration of halal integrity using blockchain technology will be relatively easy.

In the downstream supply chain network perspectives, the awareness of halal integrity from customers is more prominent in the chicken slaughtering industry than the pharmaceutical industry. Most customers are based locally in Indonesia. Indonesia is currently the leading country with the highest Muslim population and makes up 12.7% of the global Muslim population in 2010 (Pew Research Center, 2011). Meanwhile, in pharmaceutical industry, the halal authenticity of raw materials needs to be ascertained. Failure to ensure that the halal requirements are met will have a major effect on the halal integrity in the downstream supply chain network. The perspectives demonstrate the importance of implementing a secured chain such as blockchain technology to assure halal integrity in the food and pharmaceutical supply chain networks.

Table 2. A summary of the disparate and cross-case analysis of up and downstream networks

Case	Upstream	Downstream
Case 1 (Pharmaceutical industry)	<b>Key suppliers:</b> powder medicinal ingredients <b>Sources of materials:</b> More than 70% of main raw materials are supplied with overseas suppliers	<b>Key markets:</b> Europe, Asia and Pacific, and Indonesian market <b>Market channel:</b> Overseas and domestics, approximately market in 40% are local in Indonesia and 60% are exported
	<b>Awareness of halal integrity from suppliers:</b> high to ensure the halal ingredients of raw materials.	<b>Awareness for halal integrity from customers:</b> relatively high to increase transparency and trust with customers
	<b>Perceived benefits of halal integrity using blockchain application:</b> the existence of halal authenticity, transparency and trust, traceability system and integration with suppliers will increase using blockchain applications	<b>Perceived benefits of halal integrity using blockchain application:</b> transparency and trust and traceability system with customers will enhance using blockchain applications
	<b>Priority implementation of halal integrity using blockchain application:</b> still not implemented but have implemented traceability system. The upstream side of the supply chain	<b>Priority implementation:</b> second priority after implementation in upstream supply chain

Case	Upstream	Downstream
	is preferred as the first phase of implementation	
Case 2 (food industry)	<b>Key suppliers:</b> chicken boiler farming <b>Sources of materials:</b> 100 % of raw materials from domestic	<b>Key markets:</b> Indonesian market <b>Market channel:</b> Domestic, 100% are distributed in Indonesia
	<b>Awareness for halal integrity from main supplier:</b> relatively moderate for halal but high for food safety	<b>Awareness for halal integrity form customers:</b> high
	<b>Perceived benefits of halal integrity using blockchain application:</b> traceability system and integration with suppliers	<b>Perceived benefits of halal integrity using blockchain application:</b> Halal authenticity, transparency and trust, traceability system, supporting halal certification
	<b>Priority implementation of halal integrity using blockchain application:</b> upstream supply chain as the second phase of implementation	<b>Priority implementation:</b> priority to be implemented in downstream supply chain

The characteristics of the industry can distinguish the awareness and perceived benefits of halal integrity that are reached using blockchain application. Ensuring the halal ingredients of raw materials is more prominent in the pharmaceutical industry than in the food industry. However, increasing transparency and trust using a traceability system with customers is more important in the food industry than in the pharmaceutical industry. The existence of halal raw material authenticity is more important in the pharmaceutical industry. Meanwhile, supporting for halal certification and traceability system for customers is more important in the food industry.

## 5. Conclusions

This study aims to contribute to academic research by delivering the awareness, perceived benefits, and priority implementation of halal integrity using blockchain application especially in the pharmaceutical and food industry. In the upstream supply chain network, awareness of halal integrity from suppliers is more prominent in the pharmaceutical industry compared to the chicken boiler slaughtering industry. In the downstream supply chain network perspectives, the awareness of halal integrity from customers is more prominent in the chicken slaughtering industry than the pharmaceutical industry.

In conclusion, the perceived benefits of blockchain application for halal integrity are strengthening of halal authenticity, transparency and trust, traceability system and integration with their suppliers in the pharmaceutical industry. The perceived benefits of halal integrity using blockchain application in the chicken slaughtering industry are the traceability system and integration with suppliers.

## References

- Aung, M., and Chang, Y., Traceability in a food supply chain: safety and quality perspectives, *Food Control*, vol. 39, pp. 172–184, 2014.
- Ali, M. H., and Suleiman, N., Eleven shades of food integrity: a halal supply chain perspective, *Trends in Food Science and Technology*, vol. 71, pp. 216–224, 2018.
- Chandra, G., Liaqat, I., and Sharma, B., Blockchain redefining: the halal food sector, *Proceedings - 2019 Amity International Conference on Artificial Intelligence*, pp. 349–354, Dubai, UAE, February 4-6, 2019.
- Eisenhardt, K., Building theories from case study research, *Academy of Management Review*, vol. 14, no. 4, pp. 532–550, 1989.
- Elliott, C., *Elliott Review into the Integrity and Assurance of Food Supply Networks-Final Report: A National Food Crime Prevention Framework*, Department for Environment, Food & Rural Affairs Food Standards Agency, London, p 84, 2014.
- Foth, M., The promise of blockchain technology for interaction design, *ACM International Conference Proceeding Series*, pp. 513–517, 2017.

- Katuk, N., The application of blockchain for halal product assurance: a systematic review of the current developments and future directions, *International Journal of Advanced Trends in Computer Science and Engineering*, vol. 8, no. 5, pp. 1893-1892, 2019.
- Manning, L., and Soon, J., Developing systems to control food adulteration, *Food Policy*, vol. 49, no. P1, pp. 22-32, 2014.
- Pew Research Center, The Future of the global Muslim population, Available: <https://www.pewforum.org/2011/01/27/the-future-of-the-global-muslim-population/>, October 23, 2020.
- Rejeb, A., Halal meat supply chain traceability based on HACCP, *Acta Technica Jaurinensis*, vol. 11, no. 1, pp. 00-00, 2018.
- Rohmah, D., Maharani, S., Kholis, M., Taqwa, S., and Setyaningrum, H., Traceability and tracking systems of halal food using blockchain technology to improve food industry competitiveness, *Proceedings of the 1st International Conference on Business, Law And Pedagogy, ICBLP 2019. European Alliance for Innovation (EAI)*, 2019.
- Soon, J., Chandia, M., and Regenstein, J., Halal integrity in the food supply chain, *British Food Journal*, vol. 119, no. 1, pp. 39–51, 2017.
- Speranza, M., Trends in transportation and logistics, *European Journal of Operation Research*, vol. 264, no. 3, pp. 830–836, 2018.
- Tan, K., Ali, M., Makhbul, Z., and Ismail, A., The impact of external integration on halal food integrity, *Supply Chain Management*, vol. 22, no. 2, pp. 186–199, 2017.
- Tieman, M., Darun, M., Fernando, Y., and Ngah, A., Utilizing blockchain technology to enhance halal integrity: the perspectives of halal certification bodies, *BT Services – SERVICES 2019*, Springer International Publishing, pp. 119–28, 2019.
- Vanany, I., Maftuhah, D., Soeprijanto, A., and Arifin, F., Development of halal audit information system (HAIS) and its implementation evaluation based on time-cost trade-off using integer linear programming (ILP), *IEEE International Conference on Industrial Engineering and Engineering Management*, pp. 859–863, 2019a.
- Vanany, I., Maftuhah, D., Soeprijanto, A., Sukoso, and Zulhafizh, M., Modelling halal internal traceability in open source ERP system for chicken meat processing company. *IEEE International Conference on Industrial Engineering and Engineering Management*, pp. 1017–1021, 2019b.
- Vanany, I., Rakhmawati, N., Sukoso, S., and Soon, J., Indonesian halal food integrity: blockchain platform, *Proceedings of the the 2020 International Conference on Computer Engineering, Network, and Intelligent Multimedia (CENIM)*, Surabaya, Indonesia, November 17-18, 2020.
- Yin, R., *Case Study Research and Applications: Design and Methods*, 6<sup>th</sup> edition, Sage Publications, Thousand Oaks, pp. 156-165, 2017.
- Yusuf, E., and Yajid, M., Halal pharmaceuticals and cosmeceuticals from the perspective of higher education, *Asian Journal of Pharmaceutical Sciences*, vol. 11, no. 1, pp. 18-19, 2016.

## Biographies

**Iwan Vanany** is a Professor in the Department of Industrial and Systems Engineering at Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia. His research interests are in food supply chain management, business process management, and halal operations and supply chain. He has published in *International Journal of Information System and Supply Chain Management*, *Meiji Business Journal*, *Supply Chain Forum: An International Journal*, *International Journal Logistics Systems and Management*, *Journal of Islamic Marketing*, *International Journal of Lean Six Sigma*, *British Food Journal*, and *Food Control*. He teaches business process reengineering, supply chain management, enterprise resources planning (ERP), logistics system, productions and planning control, transportation, and warehouse management, and purchasing management. He can be contacted at [vanany@ie.its.ac.id](mailto:vanany@ie.its.ac.id).

**Nur Aini Rakhmawati** is an associate professor of Information Systems Department as well as vice-chair of the halal centre, Institut Teknologi Sepuluh Nopember Surabaya (ITS), Indonesia. She completed her PhD at the Insight Centre for Data Analytics, NUI Galway, Ireland, her Master at National Taiwan University of Science and Technology and her Bachelor at ITS Surabaya. Her current research interests include knowledge graph, big data, and computer ethics. She is the founder of Linked Open Data halal (<http://halal.addi.is.its.ac.id/>). She received the Neo4J Graphite Award winner (2020), ASEAN Scientist Leader Fellowship (2017), Sister Pass It on Award (2011), Grace

Hopper Scholarship (2008), N2Women Fellowship (2008) and Google Summer of Code (2007). Recently, she has been doing outreach to small and micro business in terms of Halal Assurance System implementation.

**Nandya Shafira Pramesti** is a dual master candidate from Industrial and System Engineering, Institut Teknologi Sepuluh Nopember Surabaya (ITS), Indonesia and Industrial Management, National Taiwan University of Science and Technology, Taiwan. She completed her bachelor's degree in Industrial and System Engineering, ITS. Her current research interest includes supply chain, decision analysis and inventory theory.

**Jan Mei Soon** is a leading expert in food fraud and food integrity. She was the recipient of the prestigious British Academy/Leverhulme Small Research Grant and EU Food Integrity training programme. She was recently appointed as the Register of Specialist for Food Standards Agency, UK and is also the technical expert in the Early Warning Rapid Alert Horizon Scanning group with the United Nations of Food and Agriculture Organization (FAO), Rome, Italy. To date, she has published more than 100-peer reviewed journal articles and 2 major academic books in food safety and fraud.