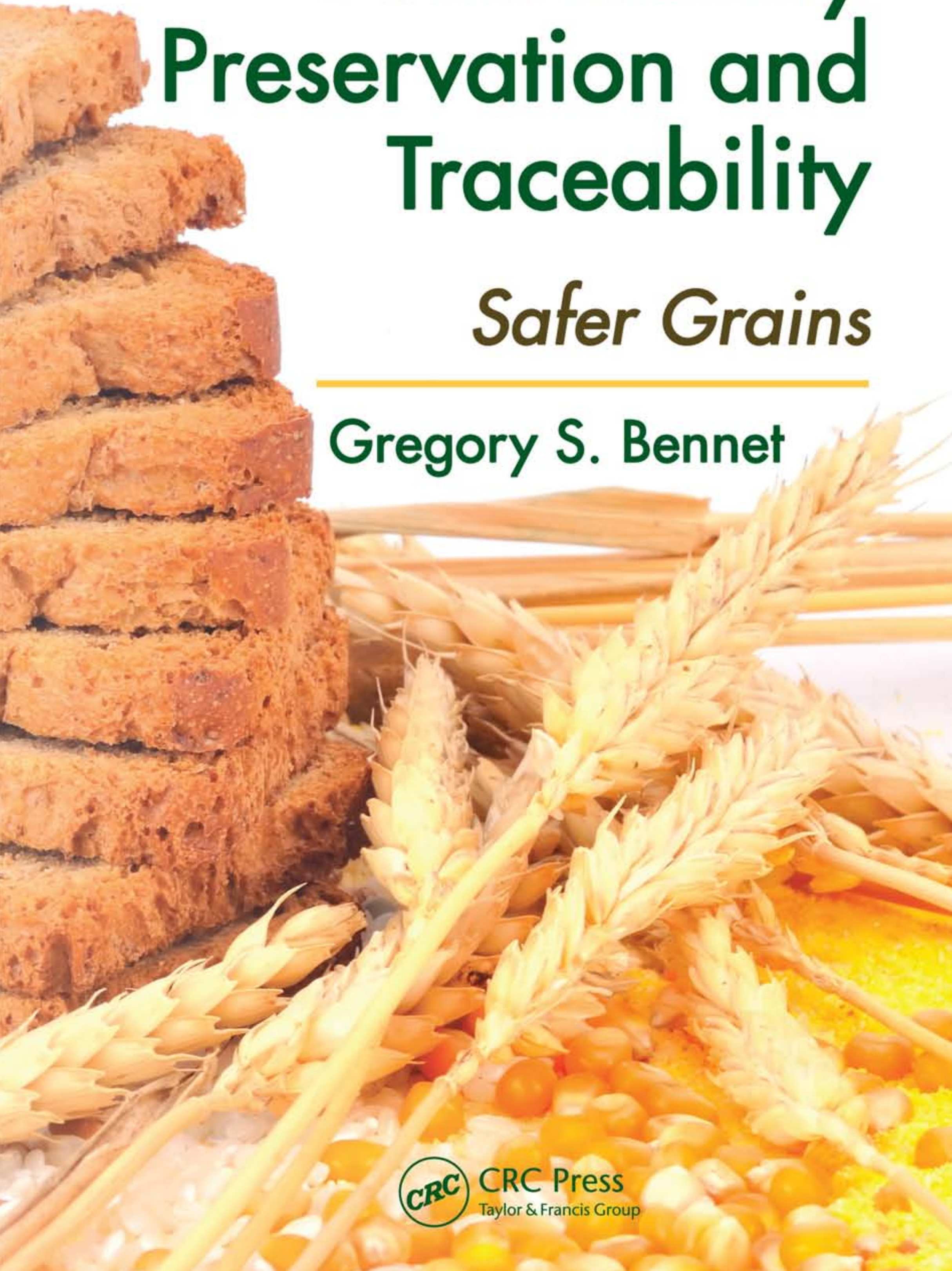
Food Identity Preservation and Traceability

Safer Grains

Gregory S. Bennet



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To my wife, Cynthia D. Bennet, who has been tremendously supportive in my research, and for her endless encouragement and patience. Words cannot express what she means to me—I am so fortunate.

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Preface

Melamine in milk, *Salmonella* in peanut products, tainted ingredients, *Aflatoxin* in pet food, counterfeit ingredients, and *Escherichia coli* found on peppers are becoming common headlines on the evening news. These occurrences will be increasingly more common as global trade of agricultural products expands. Hand in hand with this will be the nearly epidemic numbers of people becoming sick and dying from food-related safety issues. The world population is expected to reach 10 billion by 2050. Production agriculture and the food supply chain are already facing challenges because of environmental degradation and climate change, which further reduce the land available for production. Scarcity of food and greed for profit push some producers to cut safety corners or to outright substitution of inferior or counterfeit ingredients. In researching the root causes and common elements of the expanding food safety issue, I discovered how diverse, broad, and fragmented the food system was. Books on how the food safety system works with regard to how identity preservation and traceability affects food safety are few and focus on selected, more narrowly focused aspects of the food supply chain. Regulations, articles, and software packages abound regarding particular issues; yet, there is little offered that pulls the entire food safety system together. Thus, this book was written.

This book explains, in a working person's terms, the reasons why and how identity preservation and traceability helps improve food safety. The hope is that the reader may gain a better understanding of the complexity of identity preservation and traceability systems, rules that it functions under, how identity preservation and traceability is shaped and modified, and primary support and ancillary components that govern it.

The approach used to read this book is very much dependent upon the reader's needs and desires. The table of contents is key for navigation and provides the best map of the book. For those who only wish for a basic understanding of identity preservation and traceability, Part I provides the basics, history, design, and components. Part II offers abridged versions of the programs and available standards through which identity preservation and traceability navigates. Auditing and laboratory testing are becoming increasingly important and required. Part III provides an introduction and summary of the more popular auditing programs and laboratory testing services. Especially important are the outside forces that can shape identity preservation and traceability rules, regulations, and efficiency. Part IV provides the reader with a sampling of organizations that influence the direction of identity preservation and traceability, food safety policy, software systems, process facilitators, food recalls, and insurance. Part V includes research instruments for evaluating compliance, cost-benefit analyses, and farmer surveys. This work is generally encyclopedic in nature rather than narrative and is intended as a reference work. Every effort has been made to provide the identity preservation and traceability story in sequential or hierarchal order; unfortunately this is not always possible because the identity preservation and traceability story is diverse and fragmented.

Walking through a bookstore or browsing online, a reader finds numerous books and articles that highlight genetically modified organisms and food recalls. Some books and articles have titles such as from "Farm to Fork" or "From Dirt to Dinner Plate." This book goes into greater detail about the components and structure of the food supply system than previous works and, yet, without getting into too much detail, provides summaries and glimpses of rules, regulations, systems, companies, etc., that impact and contribute to food identity preservation and traceability. We have seen how the commercial market has jumped in with solutions that range from radio frequency identification technology and deoxyribonucleic acid laboratory testing to third-party auditors and network providers. None of these examples truly encompasses the enormity of identity preservation and traceability within the food supply chain. This book is the first to provide the complete story of identity preservation and traceability as it applies to food safety. Any chapter could be expanded upon and developed into a more finely focused subject. However, what makes identity preservation and traceability unique, as with this book, is in its approach—it necessitates interactions between businesses, computer systems, and policy organizations. The strength of this book is that it addresses and pulls together the various independent yet interactive parts of the food supply chain to develop a holistic view of how identity preservation and traceability contributes to food safety.

This book, although not exhaustive, is illustrative of trends. Identity preservation and traceability are not new concepts; however, the growth of public and business interest and concerns regarding identity preservation and traceability has grown tremendously during the past decade because of many food safety events. This has resulted in these concepts joining together (identity preservation and traceability) within a single concept. This book, while attempting to be thorough, will highlight selected major systems of identity preservation and traceability from a U.S. grain perspective. It is understood that fundamental identity preservation and traceability concepts follow similar systems structures regardless of product (i.e., livestock, fruits and vegetables, fish, etc.).

Most recently, identity preservation and traceability of food has fallen under regulatory requirements to protect against bioterrorism. The system of documentation is moving from paper-based to computer-or electronic-based for storage and information sharing. However, many of our more modern technology systems (computer hardware and software) are still very fragmented, discrete, and uncomplimentary in regard to integrating individual identity preservation and traceability systems with one another along the supply chain. In addition, training of management on identity preservation and traceability processes needs to be more thorough, transparent, linked, and standardized to improve interactions and performance. The cost of diverse government regulations, differing proprietary services, and incompatible commercial solutions to the consumers, companies, and the global supply chain calls for defining identity preservation and traceability as a business process. This book helps bring together not only the many primary and secondary participants but also the ancillary groups, which help shape our food supply system.

NOTE ON THE LITERATURE

This book contains information obtained from a wide variety of highly regarded references and sources. Numerous resources provided information regarding facets of identity preservation and traceability. Of special note are the works from the U.S. Department of Agriculture written by Elise Golan and others. The most comprehensive works about the state of the art of identity preservation and traceability were by Dennis Strayer, *Identity-Preserved Systems: A Reference Handbook* (2002) and *Improving Traceability in Food Processing and Distribution*, edited by Ian Smith and Anthony Furness (2006), for which I wish to thank them for their contribution to this field of research.

DISCLAIMER

The information within this book is derived from official websites and published literature as cited. Excerpts from these sources have been used and condensed for brevity and all efforts have been made to credit these sources. It is the intent of the author to not change the meaning or intent of the original work or publication. Any omissions or errors are solely the responsibility of the author; however, reasonable efforts have been made to publish reliable data and information. In addition, the author is not responsible for claims made by individuals or organizations as to being true. The use of product or service names does not imply endorsement by the author. This overview is intended to assist the reader to better understand the range and scope of identity preservation and traceability as it applies to local to global food chains.

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While I had the help and support of many people and organizations, any omissions or errors in this publication are solely my own responsibility. It is my goal to fully credit and retain the original intent of others' work that I have included in my publication. Every effort has been made to publish reliable data and information.

Author

Gregory S. Bennet had a successful military career in the U.S. Army and U.S. Coast Guard before retiring and pursuing his PhD degree. A helicopter rescue pilot, Greg was involved in the weather phenomenon now known as "The Perfect Storm." He achieved an MBA and a Master's degree in history, focusing on agricultural business. His PhD is in agricultural and biosystems engineering with a focus on sustainable agriculture. Greg and his wife Cynthia live in Ames, Iowa.

List of Abbreviations

AI—application identifier
ALOP—appropriate level of protection
AMS—Agricultural Marketing Service
APEC—Asia-Pacific Economic Cooperation
ASEAN—Association of Southeast Asian Nations
ASN—Advance Shipment Notice
BEM—biological exposure monitoring
BOL—bill of lading
BT Bt—*Bacillus thuringiensis*
CBD—Convention on Biological Diversity
CCIA—Canadian Cattle Identification Agency
CCP—critical control point
DNA—deoxyribonNucleic acid
DOA—Department of Agriculture
DOT—Department of Transportation
ECCC—Electronic Commerce Council of Canada
EDI—electronic data interchange
EIA—enzyme immunoassay
ELISA—enzyme-linked immunoabsorbent assay
EPA—Environmental Protection Agency
EPC—Electronic Product Code
FAO—Food and Agriculture Organization of the United Nations
FDA—Food and Drug Administration
FSMS—Food Safety Management System (or Standard)
GAP—Good Agricultural Practices
GATT—General Agreement on Tariffs and Trade
GC—gas chromatography
GDPs—Good Distribution Practices
GE—genetically engineered
GEPIR—Global EAN Party Information Register
GFSI—Global Food Safety Initiative
GIAI—Global Individual Asset Identifier GLN—Global Location Number
GMO—genetically modified organism
GMPs—Global or Good Manufacturing Practices
GRAI—Global Returnable Asset Identifier
GTIN—Global Trade Item Number
HACCP—Hazard Analysis and Critical Control Point
HPLC—high-performance liquid chromatography
IAEA—International Atomic Energy Agency
INFOSAN—International Food Safety Authorities Network
IP—identity preservation
IP—intellectual property
IPM—integrated pest management
IPM—integrated product management
IPPC—International Plant Protection Convention
IPT—identity preservation and traceability
ISO—International Organization for Standardization
JECFA—Joint FAO/WHO Expert Committee on Food Additives
JEMRA—Joint FAO/WHO Expert Meetings on Microbiological Risk Assessment
JMPR—Joint FAO/WHO Meetings on Pesticide Residues
MRL—maximum residue limit
NAFTA—North American Free Trade Agreement
NGO—non-governmental organization
NOP—National Organic Program
NOSB—National Organic Standards Board

OECD—Organisation for Economic Co-operation and Development
OIE—World Organization for Animal Health
OSHA—Occupational Safety and Health Administration
PCR—polymerase chain reaction
PO—purchase order
POS—point of sale
PPB or ppb—parts per billion
PPM or ppm—parts per million
RFID—radio frequency identification
RSS—reduced space symbology
SCC—shipping container code
SCC—Standards Council of Canada
SQFI—Safe Quality Food Institute
SOP—state organic program
SSCC—serial shipping container code
SSM—supportive safety measure
TBT—technical barriers to trade
TCC—Transaction Certificate of Compliance
UCC—Uniform Code Council
U.N.—United Nations
UNECE—U.N. Economic Commission for Europe
UPC—Universal Product Code
UREC—unavoidable residual environmental contamination
WHO—World Health Organization
WTO—World Trade Organization
XML—Extensible Markup Language

Section I

General Introduction

INTRODUCTION, HISTORY, AND THEORY; DESIGN; AND COMPONENTS OF IDENTITY PRESERVATION AND TRACEABLILITY

Part I of this work provides the reader with an overall introduction to identity preservation and traceability (IPT). The idea of identity preservation (IP—tracking from origin to customers), traceability (tracing from the customer to origin), and their incorporated systems and programs has become increasingly important to customers from local food markets to global traders. The first three chapters bring together the story of IPT. The first chapter provides an introduction (the fundamentals of IPT), the second chapter provides an overall historical view of how it came into being, and the third chapter covers IPT theory, design, components, an interpretation, analytical techniques, and introduction to batch processing challenges.

Although the story's origins appear fragmented and disconnected, the resultant systems and programs come together as organizations, and various entities bring forth solutions to sometimes abstract questions or demands that society asks of its food supply system.

The subsequent parts include Part II, covering IPT programs and standards; Part III, which concerns auditors and laboratories; Part IV discusses consultative and service contributors; and Part V covers scorecard matrices, spreadsheets, and questionnaires. At the very end is the interpretation and conclusions.

A reminder to the limitations of this work: this section is not designed to be interpretive or judgmental. The goal of the main body of the state of the science is to provide an introduction to and summary of IPT systems and programs available and develop a conceptual model of IPT at the farmer level. Interpretations regarding the IPT are at the end of this work.

1 Introduction to Identity Preservation and Traceability

1.1 INTRODUCTION TO IDENTITY PRESERVATION AND TRACEABILITY

This work attempts to describe the who, what, where, when, and why of identity preservation and traceability (IPT) as it applies to the food chain up until early 2007. The perspective is primarily of a U.S. grain production viewpoint. However, many other views are included.

The information obtained is derived from official websites and published literature. Excerpts from these sources have been used and condensed for brevity, and all efforts have been made to credit these sources. It is the intent of the author to not change the meaning or intent of the original publication. Any omissions or errors are solely the author's. However, the author is not responsible for claims made by individuals or organizations as to being true. This work is a compilation of many diverse entities that go into an IPT system. This overview is intended to assist and better understand the range and scope of IPT.

So what is IPT? First, we must explain each of these terms.

1.2 IPT SYSTEM

IPT is considered a market solution system (singular) that answers two market needs. The first, identity preservation (IP), holds the notion that any given product has a value (which is desirable to maintain for various consumers), from less valuable commodity grains—U.S. Department of Agriculture (USDA) inspected—to more valuable specialty crops (e.g., organic certified). To accomplish this, businesses implement systems to preserve particular trait(s) and credence attribute(s). The second market need, traceability, is needed for business logistics purposes and many times is required by food safety regulations. For business, this represents inventory control and a method to recall defective products; for food safety, this represents the mechanism during an outbreak of disease to remove affected products and locate the source of contamination. For food chain participants, the tracking (from seed to plate) and tracing (from outbreak to source) often entails using one and the same paper and/or electronic documentation procedures, tests, certifiers, etc. IPT represents a system or program in which industry can meet the traceability requirements that society demands and also profit, with overlapping systems, by providing increased identity-preserved product for lower costs.

IP envelops the idea that specific traits and/or credence attributes are important for various customers to maintain or realize. Often the term "value-added" is used, especially to connote an economic aspect of a trait for the farmer, processor, or society. For soybean or corn farmers, the traits of interest when they purchase their seeds may include oil and protein content of harvested crop, harvest yields, drought tolerance, Roundup Ready, etc. Farmers hope to gain increased profits from greater yields or less use of pesticides. For grain elevators, the traits of interest may be in accepting yellow versus white corn, genetically modified (GM) grain versus non-GM grain, etc. The difference in quality and content may affect income from contracts. For processors, the traits of interest may be starch content, or how well certain varieties process or extend shelf life.*

In addition to physical traits of interest, there are "credence attributes" of interest. Crop or product innovations may involve credence attributes, characteristics that consumers cannot discern even after consuming the product. Credence attributes can describe content or process characteristics of the product. ***Content attributes*** affect the physical properties of a product, although they may be difficult for consumers to perceive. For example, consumers are unable to determine the amount of isoflavones in a glass of soymilk, or otherwise distinguish between conventional corn oil and oil made from genetically engineered (GE) corn. ***Process attributes*** do not affect final product content but refer to characteristics of the production process. Process attributes include country of origin, organic, free-range, animal welfare, dolphin-safe, shade-grown, earth-friendly, wage and fair-trade, etc. In general, neither consumers nor specialized laboratory testing equipment can detect process attributes. Governments may also be interested in the origins of the food or origins of a particular process, thus providing a form of brand or regional name of value and labeling regulations. All of these traits, many others not mentioned, and some yet to be determined, are traits and credence attributes that comprise identity preserved products† (Golan, Krissoff, and Kuchler 2004).

Third-party verification may be used to ensure credence attributes or content attributes that are difficult or costly to measure. The only way to verify the existence of these attributes is through recordkeeping that establishes their creation and preservation. Government may also require that firms producing foods with credence attributes substantiate their claims through mandatory traceability systems; for example, some governments require that firms producing organic foods verify their claims. If firms are not required to prove that credence attributes exist, some may try to gain price premiums by passing off standard products as products with credence attributes (Golan, Krissoff, and Kuchler 2004).

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* These are terms used throughout this paper. Sometimes genetically modified organism (GMO) and GM are used interchangeably. I attempted to standardize their use but reverted to using the same description as the organization uses the term. Therefore, if there is a noted difference throughout the book, it is because of the organization's use of a term.

† Functional Food—New concepts like functional food, nutraceuticals, fortified foods, and dietary supplements are created by the industry trying to open new market segments.

1.3 THE DILEMMA: WHAT CONSUMERS WANT AND ARE WILLING TO PROVIDE FOR

For IP to be credible, it must have a tracking mechanism and be profitable. The term "IP-*T*" is used here to represent IP and its tracking mechanism. Generally, IP-*T* works from the food origins, includes many processes and events, and continues up until the final purchase. It is the way that IP products retain their value-added qualities or credence attributes. On the other hand, traceability (sometimes referred to as "back-tracing") works in the opposite direction—from consumer or store shelf backward to the food or ingredient's origin or source. Traditionally this has been used for business logistics to know when a product was sold or ingredient consumed. As in recent food scares, traceability has been used for food recalls, mislabeling, etc., and has been used as a tool to more quickly remove selected products from the market.

1.4 THE SECOND PART OF IPT IS TRACEABILITY

Traceability has existed for years, although it has and does go by other names such as logistics control, inventory management and, on the food safety side, involves product recalls. Historically, when a defect or mislabeling occurred the firm recalled the defective product. When the defect or contamination was found, the organization would attempt to "back trace" to locate the source of deficiency. Lots, batches, pallets, and production lines would be involved and checked. Traceability uses informal (industry) and formal (national) rules and regulations. Traceability mechanisms were traditionally regulated primarily by industry; however, because of recent food security issues, the guiding force behind mandatory traceability has been government.

Many organizations are developing or including a system, be it under quality control, safety, etc., that utilizes both an IP tracking IP-*T* system (this may include documentation, audits, and laboratory testing) and traceability (back-tracing) system (this too may include, but to a lesser degree, documentation, audits, and laboratory testing).

As unique and different as IPT systems are from each other, they both utilize many of the same concepts and processes, documentation, third-party audits, laboratory tests. Each of these concepts may start from opposite ends of the food chain from one another; however, each system will incorporate the functions of documentation, auditing, and tests to insure IP or traceability (see Figure 1.1 for illustration).

<u>Terminology Review</u>

Identity Preservation (IP): Trait(s) and/or credence attribute(s) of interest.

Identity Preservation-Tracking (IP-*T*): Mechanisms that track product or ingredient from origin to customer.

Traceability (T): Mechanisms that trace product or ingredient from shelf backward to origin or source; for example, from a consumer or point of food safety event back through the various processes and players, then back to the source of defect.

Identity Preservation & Traceability (IPT): Includes the mechanisms that enable both way tracking and tracing by paper and/or electronic trails, and may include third-party audits and laboratory tests. The mechanisms that track forward or trace backward need not be exclusive.

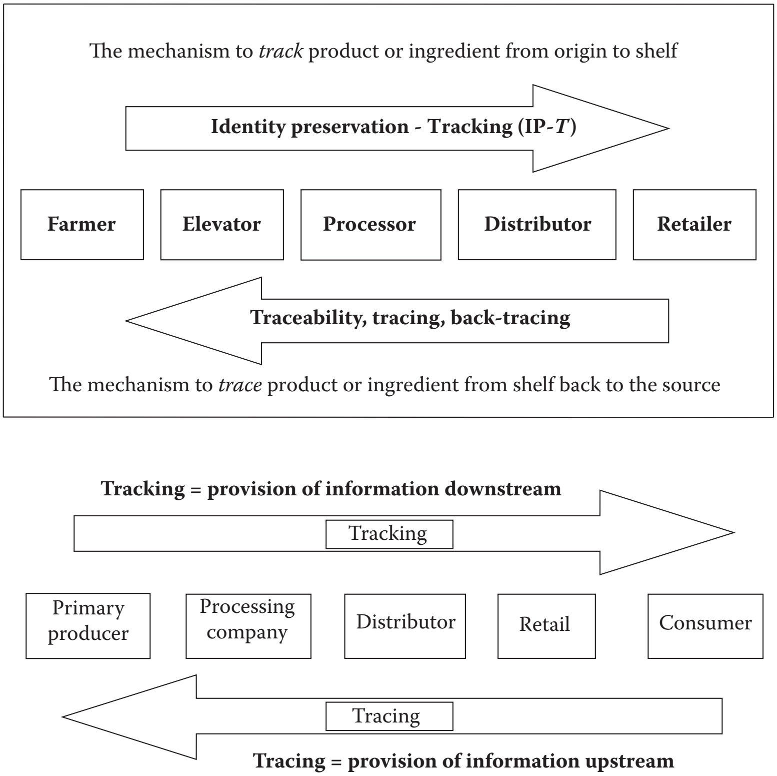

FIGURE 1.1 Terminology review. (Reprinted from Schwägele, F, *Meat Science* 71, 164–173, 2005. With permission.)

1.5 AN IMPORTANT NOTE

Many published works use the terms "track" or "trace" interchangeability when pursuing forward or backward information of a product or ingredient within the food supply chain. Thus it is important to understand for what purpose(s) the tracking or tracing is being used. For this book, *tracking* will always be regarded as the mechanism used to follow a product or ingredient; for example, from seed through various processes and entities on until the product is purchased. *Tracing* will always be regarded as the mechanism used to follow a product or ingredient from the point of sale or concern (e.g., mislabeled product on shelf) backward through the various entities, processes, and players, on until the source of defect or event origins.

Another good pictorial example of how both tracking and tracing systems work together is from John Deere FoodOrigins' illustration (Figure 1.2). Although they use this diagram to promote their own IPT software program, the illustration does graphically point to the connectivity of the food supply chain and how easy it would be, in the case of recall, to recall nontargeted product or ingredient, which was not involved with recall, merely because it was a similar or like ingredient. This was the

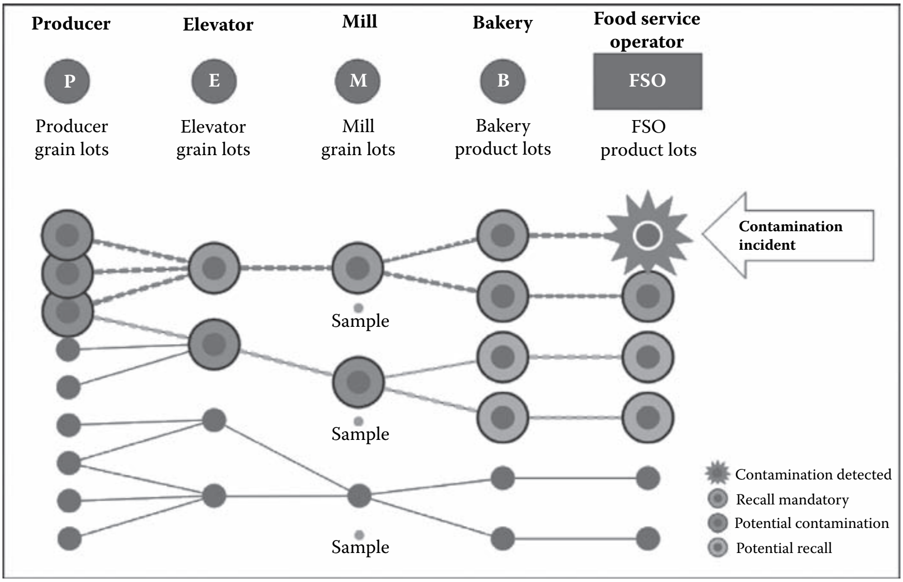

FIGURE 1.2 FoodOrigins' tracking and tracing. (From Bantham, A. "Rapid Response—Identification and Isolation." In *International Food and Agribusiness Management Association Deere & Company USA*, Slide 11, 2004.)

case with the 2006 spinach recall in the United States, in which nearly all spinach was recalled because of weak traceability programs by that industry.

1.6 WHY IPT CAME INTO EXISTENCE

Food security has long been an issue for society. For the most part, local governments through laws and codes tailored food safety to meet local needs that dealt with growing, cooking, labeling, and packaging of food. Usually this was enough, or at worst kept pace to meet situations such as regional disease outbreaks, mislabeled products, or production hygiene issues. However, most recently two major events affecting two different large regions have affected local, national, regional, and international consumers. (Chapter 6 provides greater detail of how the various standards are implemented.)

In Europe, the crisis that damaged the public's confidence in their food safety was the outbreak of bovine spongioform encephalopathy (BSE), or "mad cow disease", which overwhelmed authorities. As perceived by the populace, government could not handle the outbreak, was ill prepared, and fell short of expectations in protecting consumers. The drive for strict standards imposed by the grocery industry across Europe was furthered by a series of food safety crises, including diesel fuel in palm oil, sewage waste in feed, *Listeria* in cheese, *Salmonella* and antibiotics in poultry, and *Escherichia coli* in animal meat, which undermined consumer confidence in their food supply (Moe, 1998). Shortly after these food crises, activists and environmentalists pointed toward the next possible threat to the food supply and the environment—genetically modified organisms (GMOs). These groups' concern was well justified, as far as governments' ability to conduct proper oversight and protect its people because governments fell short of expectations. Governments and the food industry let the customer or consumer down. These groups gained a greater voice in heralding the dangers of GMOs and pressured European producers to restrict perceived unsafe, untested food products. A decade of food safety scares, and well-organized "green" and consumer movements in Europe revolving around food crises, have had greater results than pressures put on American producers. Thus, European agriculture moved more aggressively to institutionalize changes than the United States. Europe's approach to food safety is in its mandatory government mandate of rules and laws, which involve documentation, testing, tolerances, and labeling. To protect its food system the European Union (EU) uses the "precautionary principal" to guide it in its determination of whether or not a food is safe (Glassheim, Nagel, and Roele 2005).

The United States has had its share of food safety incidents, although none reached the near panic level of concern that was felt in Europe toward food safety. However, for the United States, the attacks on the World Trade Center's twin towers and Pentagon on September 11, 2001 heightened the government's and public's concern over food safety issues because of terrorism, and more specifically, bioterrorism. The notion that terrorists could contaminate crops and livestock along any part of the food supply chain scared authorities. The solution was not much different than that of European authorities' traceability and the ability to trace food products backward. The major difference in philosophy between the United States and Europe is that in Europe the rules of how to accomplish compliance are most often determined or directed by government. In the United States, the government determines the requirements or criteria and lets the market (i.e., industry, producers, etc.) determine the best course of action or how to meet government mandates. Regarding GMOs, for Americans, the risks and threat from GMOs are minimal. Americans have had years of GMO use and consumption, so aside from government approval for various crops used for human or animal consumption, labeling of GMO content is not required. The notion of "substantially equivalent" is how the U.S. government views approved GMO products.

For the Australian food industry, additional examples of recent food safety incidents illustrate the need for greater emphasis on food safety, including: (1) the 1995 *Garibaldi* incident, in which one person died and 23 people were hospitalized; (2) the 1996 salmonellosis scare in peanut butter; and (3) the endosulfan scare, in which endosulfan was detected in meat for export. Other food safety incidents raised public awareness of these issues as well, and thus all manufacturers are extremely conscious of what the implications are if such a food safety incident should occur in their industry (Smith 1998) (see Chapter 6 on the SQF Institute).

Since the occurrences of many of the above incidents, follow-up issues of tracking food shipments to reduce the risk of tampering, and on traceability systems to detail country of origin, animal welfare, and genetic composition have become paramount. In addition, tracing particular risks identified in the areas of chemical hazards (chemical residues, weed seed toxins) and microbiological hazards (mycotoxins and *Salmonella*) have been included in many countries' new and improved food safety regulations. Heightened awareness of food-related safety issues among today's consumers, coupled with a more educated public, is driving the demand for more information about food's vertically integrated supply chain. Recent animal health and food-borne illness scares in all parts of the globe are creating a demand for source verification, food safety, and supply chain identification of food products.

There are several factors driving food safety. They include the following:

- Increased consumer awareness
- Tighter government regulations
- Increased scientific knowledge and more accurate methods of testing
- Increased publicity given to food safety incidents in recent years
- Increased number of value-added products on the market

1.7 TOWARD CONSUMER SOLUTIONS—SAFETY AND CONSUMER CHOICE

The increasing implementation of Good Manufacturing Practice (GMP) and International Organization for Standardization (ISO) 9000 quality management in food manufacturing have resulted in traceability systems becoming more advanced and involving increased amounts of information and more steps in the production chain. However, the BSE crisis and debates about transgenic crops have drawn new attention to chain traceability (Moe 1998). Increased awareness of food safety issues among consumers, along with a more educated and informed public, is driving the demand for more information about the food supply chain. Recent animal health and food-borne illness scares from all corners of the world are creating increased demand for source verification, food safety, and supply chain identification of food products. Although most industries and governments have established processes and systems to ensure food quality and safety (i.e., Hazard Analysis and Critical Control Points, or HACCP), these systems are often applied independently at various points in the food continuum. Traceability systems assist by making the necessary linkages between a specific product and the application of these food safety and quality assurance systems at various points along the food continuum (Can-Trace website).

From a public health perspective, improving the speed and accuracy of tracking and tracing food items can help limit the risk associated with a failure in the system. Rapid and effective traceability can also minimize the unnecessary expenditure of private and public resources and reduce consumer concerns. Furthermore, tracing food items may help public health services and industry operators in determining potential causes of a problem, thereby providing data to identify and minimize food-borne public health hazards (Can-Trace, http://www.can-trace.org).

1.8 TRACEABILITY BENEFITS FOR BUSINESS

Traceability provides many potential benefits for business, including

- Meeting regulatory requirements
- Recall and risk management: perception related to reduced risks

- Process improvements—efficiency and quality: improved customer service/ response time
- Addressing customer and market needs

The last bullet highlights where businesses can benefit from government-required traceability mandates by businesses being able use their traceability infrastructure to focus on customer and market needs, which attest to prescribed traits and credence attributes of interest. This notion of providing what can be considered value-added often results in a new profit center for the company and additional benefit to consumers, the environment, animals, the region, etc.

Thus, from a business perspective, the requirements of government to enforce traceability regulations and resultant corporate infrastructure to support this mandate help facilitate the aspects of IP of traits and credence attributes of interest. A business or corporation that effectively combines both traceability and IP is said to have a bidirectional IPT program or system.

1.9 WHAT HAS BEEN ESTABLISHED IN RESPONSE TO FOOD CRISES—WHAT IS OUT THERE?

Globally, many changes have occurred regarding traceability during the past decade. Still, nations and regions around the world have reacted in different ways. Of particular clarity is Guillaume P. Gruère's work (2006) titled *An Analysis of Trade Related International Regulations of Genetically Modified Food and their Effects on Developing Countries*, which provides an excellent overview of traceability country by country. According to Gruère, because of consumer, environmental, ethical or political reasons, many countries have adopted stringent regulation regarding the approval and marketing of food and feed products, especially those derived from GM origins.

International regulations of GM food vary widely among developed countries. In particular, the EU and the United States have adopted different approaches on the marketing of GM food. EU regulations follow an approach based on the "precautionary principle" and consumers' "right to know," with stringent approval, labeling, and traceability standards on any food produced from or derived from GM ingredients. By contrast, the U.S. regulatory approach is based on differences in end-product characteristics and includes a voluntary safety consultation and voluntary labeling guidelines for GM food.* Most other developed countries, including Japan, Canada, or Australia, have introduced intermediary regulations that fall between mandatory and voluntary systems (Gruère 2006).

In the developing world, some of the large agricultural traders (such as Brazil) have developed biosafety and marketing regulations of GM food, but at the same time many other developing countries have not adopted any specific regulation of GM food because they lack the capacity to do so, or perhaps they have adopted a position of "wait and see" (Gruère 2006).

* Regarding labeling, nonsubstantially equivalent GM foods have to display the difference with conventional products, but there is no labeling requirement related to the fact that they were produced with genetic engineering.

As of 2005, 10 years after the introduction of the first GM crop, from nation to nation there is large variation in the regulation of GM food. At a macro level, countries can be divided as follows into three groups according to the status or type of their regulations: (1) countries with a comprehensive and stringent regulatory framework applied to GM food, including mandatory safety approval and mandatory labeling; (2) countries that have adopted a more pragmatic regulatory approach on the basis of the notion of substantial equivalence with voluntary labeling instead of mandatory labeling for GM food; and (3) many countries either without regulations or pending toward adopting certain regulations on GM food approval and marketing. Currently, developed countries are in the first and second group, whereas most developing countries are in the third group, with a few notable exceptions. The distinction between voluntary and mandatory labeling is important, because it drives several necessary regulatory requirements. *Mandatory* labeling requirement affects the whole agrofood channel from the retailers to the producers, requiring them to acquire and transmit information about the presence or origin for each food product, whereas *voluntary* labeling is driven by private incentives and the presence of market niches for non-GM food* (Gruère 2006).

Among the countries with regulations, there are two main groups of countries: those that rely on a test of substantial equivalence (substantial equivalent products are exempt from specific requirements) and those that generally do not and whose regulatory procedure depends on the production process (which means that any food produced with or derived from transgenic crops is subject to GM food regulations). Each country has also adopted its set of safety approval and labeling policies with specific characteristics. More stringent regulations will generally require more costly procedures on behalf of exporters and more comprehensive policies may have a more important trade effect (Gruère 2006).

The large producers and exporters of GM crops have well-defined regulations, but most of them are in Group 4 (Canada, United States, Argentina, South Africa), with pragmatic regulations of GM food, whereas the last two are in Group 2 (Brazil and China), with stringent regulations.

National regulations reveal that there is a large variation in regulations among countries, first in terms of development stages of regulatory framework, and second between countries with well-defined regulations. Developed countries differ in their general approach of regulations, with most GM producers and exporters in groups with pragmatic regulations whereas importers tend to have more stringent marketing regulations for GM food and GM derived products. Developing countries tend to have fewer regulations in place (Gruère 2006).

1.10 STANDARDS—REACTIONS TO FOOD SAFETY CRISES

For expanded information on standards see Chapter 6 on standards, which highlights and reviews various standards (i.e., United States, Canada, EU, international, organic, and regional, and religious).

* For more information on an economic comparison between voluntary and mandatory labeling, see Runge and Jackson (2003) and Carter and Gruère (2003).

ISO has referred to traceability in such a manner that others have borrowed from them.* ISO, which develops voluntary international standards for products and services, defines traceability as the "ability to trace the history, application, or location of that which is under consideration." This definition is quite broad. It does not specify a standard measurement for "that which is under consideration" (a grain of wheat or a truckload), a standard location size (field, farm, or county), a list of processes that must be identified (pesticide applications or animal welfare), or a standard identification technology (pen and paper or computer). It does not specify that a hamburger be traceable to the cow or that the wheat in a loaf of bread be traceable to the field. It does not specify which type of system is necessary for preserving the identity of tofu-quality soybeans, controlling the quality of grain used in a particular cereal, or guaranteeing correct payments to farmers for different grades of apples. This leaves much to be determined by producers, governments, and consumers (Golan, Krissoff, and Kuchler 2004).

According to Jenkins (2003), overall governmental traceability programs have focused on bioterrorism, GMOs, country-of-origin labeling (COOL), biofarming, overall food safety, and legislation to monitor the industry, which has created a more informed consumer base and that contributes to a shift in global food supply networks. Furthermore, consumers exert pressure on farmers, food processors, and manufacturers because of concerns about overall safety and genetic heritage of the groceries they purchase. Food producers differentiate products over a wide variety of quality attributes (taste, texture, nutritional content, origin); consumers can easily detect some attributes (color, etc.) but other innovations involve credence attributes (i.e., characteristics that consumers cannot discern even after consuming the product). Identification and traceability are essential for marketing food products, and, if food products are being differentiated via content and/or process credence attributes, record keeping, auditing and validation are essential elements of verification for IP and authenticity management (Smith et al. 2005).

1.10.1 EU Perspective

On the European continent, the general public has demanded increased food safety because of several food crises. Governments' response has been to establish traceability systems that provide information on origin, processing, retailing, and final destination of foodstuffs. Such systems enhance consumer confidence in food and enable the regulatory authorities to identify and withdraw health hazards from the market. Animal feeds are an element in this ''food-to-farm'' approach to public health. Such feedstuffs are preliminary elements of some foods for human consumption and hence are an inherent element of the food chain. A harmonized EU food traceability protocol greatly assists authorities in detecting fraud and dangerous substances. The food chain comprises a range of sequential and parallel stages,

* Some believe that ISO, as an international organization consisting of individual countries with equal voting rights or equal rights to voice concerns and participate, is a more democratic venue and less biased in their judgments.

bridging the full spectrum from agricultural production to the consumable foodstuffs by consumers* (Schwägele 2005).

The General Food Law (i.e., Regulation (EC) 178 (2002)) of the European Parliament and the Council outlines the general principles and requirements of food law, establishes the European Food Safety Authority (EFSA), and provides procedures in matters of food safety (i.e., among other things, the implementation of traceability systems in the food and feed supply chains in Europe) (Schwägele 2005).

The EU traceability legislation consists of four major points (excerpts and condensed from Schwägele 2005):

1. The *traceability* of food, feed, food-producing animals, and any other substance intended to be, or expected to be, incorporated into a food or feed shall be *established at all stages* of production, processing, and distribution.
2. Food and feed business operators *shall be able to identify any person* from whom they have been supplied with a food, a feed, a food-producing animal, or any substance intended to be, or expected to be, incorporated into a food or feed. To this end, such operators shall have in place systems and procedures that allow for this information to be made available to the competent authorities on demand.
3. Food and feed business operators *shall have in place systems and procedures to identify the other businesses* to which their products have been supplied. This information shall be made available to the competent authorities on demand.
4. Food or feed that is placed on the market or is likely to be placed on the market in the community *shall be adequately labeled or identified to facilitate its traceability*, through relevant documentation or information in accordance with the relevant requirements of more specific provisions.

1.10.1.1 Traceability along the Full Supply Chain

To be able to trace products and retrieve related information, producers must collect information and keep track of products during all stages of production (primary production, processing, distribution, retailing, and consumer). Therefore, traceability can be divided into two key functions: tracking and tracing.† Tracking can be defined as the ability to follow the path of an item as it moves forward through the supply chain from its origin to the shelf. Tracing is just the opposite and incorporates the ability to identify the origin of an item or group of items, through records, backward through the supply chain‡ (Schwägele 2005).

Aside from mandated traceability, and depending upon the IP trait(s) or credence attribute(s) of interest, other process verifications and tests may need to be used. For

* Reprinted from Schwägele, F. "Traceability from a European Perspective." *Meat Science* 71, 2005: 164–173. Copyright 2005 with permission from Elsevier.

† This is the case where the term "traceability" incorporates the notion of tracking (origin to shelf) and tracing (shelf to origin).

‡ The General Food Law covers the entire supply chain [Regulation (EC) 178 (2002), Article 18, paragraph 1].

example, within the EU, both farm and environmental sustainability have become hot topics. However, the meaning of sustainability differs from country to country.* In short, the idea of sustainability, in its broadest sense, should include elements of environmental health, societal and rural development, animal welfare, food quality and safety, and human health issues, which may require protocols, tests, and audits outside of normal food safety mandates (Glassheim et al. 2005).

1.10.1.2 EU Social Agenda

Within the EU, some see non-food safety issues or credence attributes as conflict of interests for society. This pressure is increased because of the tension between the expectations of the "citizen" and the "consumer" as two sides of mankind. For example, the citizen expects animal welfare, care for the environment, a nice landscape, and if possible, an organic agriculture. On the other hand, the consumer is not always prepared to pay an adequate price for these demands. Many producers find themselves caught between these two expectations, often mentioning that foreign competitors can sell food at lower prices because they have fewer environmental rules. Sometimes this is true, sometimes not. Psychologically, many farmers feel trapped between the supermarket (as a representative of the consumer) and the government (as a representative of the citizen). Within the EU, as in many other countries and regions, credence attributes of a social nature take on greater importance, especially when they have to do with local communities benefiting from brand naming their prized local product to the area or brand naming a process, plant, animal, or quality to that area or region. This represents an economic force that governments are dealing with (Glassheim et al. 2005).

1.10.2 U.S. Perspective

The events of September 11, 2001 in the United States caused Congress to recognize that safety of the nation's food supply could be compromised easily by a bioterrorist attack. In response, the U.S. Congress passed into law the Public Health Security and Bioterrorism Preparedness and Response Act on June 12, 2002. Under that law, the U.S. Food and Drug Administration (FDA) has authority to order the detention of any food if, as determined during an inspection, examination, or investigation, there exists "credible evidence or information" indicating that the article "presents a threat of serious adverse health consequences or death to humans or animals" (Smith et al. 2005).

Golan et al. (2004) concluded that U.S. private-sector food firms are developing, implementing, and maintaining substantial traceability systems designed to (1) improve food supply management, (2) facilitate trace-back for food safety and quality, and differentiate and market foods with subtle or undetectable quality attributes. Despite this, and although the United States has typically set the operating

* In northern Europe, talking about sustainability is commonly considered a discussion about environmental affairs. In southern Europe, more attention is paid to social issues. The discussion about sustainability can also be divided into two "mental maps": one group of people is in search of concrete, consistent, and scientific definitions of what sustainability is. The other group considers sustainability more as a process, even a political or societal process.

standard for international food handling, the U.S. food industry has been lagging in regards to food traceability. There is currently no standard process that identifies a traceable product, nor brand or social equity product.*

Studies within the United States have shown that (1) traceability is an objective-specific concept, (2) that the private sector in the United States has developed a significant capacity to trace, and (3) industry/product characteristics lead to systematic variation in traceability systems. Golan et al. (2004) found that efficient traceability systems vary across industries and over time as firms balance costs and benefits to determine the efficient breadth, depth, and precision of their traceability systems.

Government may consider mandating traceability to increase food safety, but this may impose inefficiencies on already efficient private traceability systems. The widespread voluntary adoption of traceability complicates the application of a centralized system because firms have developed so many different approaches and systems of tracking. If mandatory systems do not allow for variations in traceability systems, they will likely end up forcing firms to make adjustments to already efficient systems or creating parallel systems (Golan et al. 2004).

Not unlike the EU, fines become the tool of government to modify business behavior. Policy aimed at increasing the cost of distributing unsafe foods (e.g., fines or plant closures) or policies that increase the probability of catching unsafe food producers (e.g., increased safety testing or food-borne illness surveillance) also provide firms with incentives to strengthen their traceability systems. When the cost of distributing unsafe food goes up, so too do the benefits of traceability systems (Golan et al. 2004).

Although governments may define regulations, these are but tools for achieving several different objectives while dealing with a complex problem. As a result, no traceability system is complete. Even a hypothetical system for tracking beef, in which consumers scan their packet of beef at the checkout counter and access the animal's date and location of birth, lineage, vaccination records, and use of mammalian protein supplements, is incomplete. This system does not provide traceability with respect to bacterial control in the barn, use of genetically engineered feed, or animal welfare attributes like hours at pasture. This form of traceability is based on fulfilling regulatory requirements, which are generally broad and provide minimal hurtles, but to the contrary, IPT systems are usually tailored to customers' wants and their ability or willingness to pay (Golan et al. 2004).

A key notion with U.S. traceability is flexibility. A single system for tracking every input and process to satisfy every objective would be enormous and very costly. Consequently, firms across the U.S. food supply system have developed varying amounts and kinds of traceability. Firms determine the necessary breadth, depth, and precision of their traceability systems depending on characteristics of their production process and their traceability objectives. For example, an important aspect of developing regulations is appropriate focus. One difficulty with mandatory (EU) traceability is that they often fail to differentiate between valuable quality attributes (those for which verification is needed) and less valuable attributes for which no

* G. Smith et al., 2005 cites the Sparks 2002 publication, *Food Traceability: Standards and Systems for Tracing and Tracking Food and Agri-Products*. Memphis, TN: Sparks Companies, Inc.

verification is needed. This can be very costly for business and hurt trade or provide an unfair advantage to competitors* (Golan et al. 2004).

Within the United States, firms build traceability systems, aside from fulfilling rules and regulations toward food safety, to also improve supply-side management and construct lower-cost distribution systems. But simply knowing where a product is in the supply chain does not improve supply management unless the traceability system is paired with a real-time delivery system or inventory-control system (Golan, Krissoff, and Kuchler 2004 and Golan et al. 2004). A vital element of any supply management strategy is the collection of information on each product from production to delivery or point of sale; the idea is "to have an information trail that follows the product's physical trail." Throughout the food industry, companies are adopting new electronic traceability systems to track production, purchases, inventory, and sales to provide a basis for good supply management, allowing them to more efficiently manage resources (Smith et al. 2005).

1.10.2.1 U.S. Industry Efforts to Encourage Differentiation

Third-party entities provide objective validation of quality attributes and traceability systems. They reassure input buyers and final consumers that the product's attributes are as advertised. Third-party verification of credence attributes can be provided by a wide variety of entities, including consumer groups, producer associations, private third-party entities, and international organizations. For example, Food Alliance and Veri-Pure, private for-profit entities, provide independent verification of food products that are grown in accordance with the principles of sustainable agriculture. Third-party entities certify attributes as wide ranging as kosher, free-range, location of production, and "slow food." Governments can also provide voluntary third-party verification services. For example, to facilitate marketing, producers may voluntarily abide by commodity grading systems established and monitored by the government (Golan et al. 2004).

In some cases (e.g., branded pork, beef for export), verification is required. "To verify" is defined as "to prove the truth or accuracy of, or to substantiate, by the presentation of evidence or testimony." Source verification requires substantiation of the origin (e.g., breed, strain, geographic area) of the livestock, poultry, or meat.

* According to Smith et al. (2005), traceability of a food consists of development of "an information trail that follows the food product's physical trail," which may include process changes of importance to the customer and/or government regulations. Traceability (for livestock, poultry, and meat) in its broadest context, can, could, or will eventually be used (1) to ascertain origin and ownership and to deter theft and misrepresentation of animals and meat; (2) for surveillance, control, and eradication of foreign animal diseases; (3) for biosecurity protection of the national livestock population; (4) for compliance with requirements of international customers; (5) for compliance with country-of-origin labeling requirements; (6) for improvement of supply-side management, distribution/delivery systems, and inventory controls; (7) to facilitate value-based marketing; (8) to facilitate value-added marketing; (9) to isolate the source and extent of quality-control and food-safety problems; and (10) to minimize product recalls and make crisis management protocols more effective. Domestically and internationally, it has now become essential that producers, packers, processors, wholesalers, exporters, and retailers ensure that livestock, poultry, and meat are identified; that recordkeeping ensures traceability through all or parts of the complete life cycle; and residuals that, in some cases, the source, the production-practices, and/or the process of generating final products, can be verified.

Production practice verification involves authentication of things done (e.g., grass-fed, free-range, raised/handled humanely) or things not done (e.g., no antibiotics, no hormonal growth promoters, not fed animal byproducts) during rearing of the animals. The USDA Process Verification Program (PVP) provides suppliers of agricultural products the opportunity to assure customers of their ability to provide consistent quality products. The PVP is accomplished by having documented manufacturing processes verified through independent, third-party audits, and it enables suppliers to make marketing claims (e.g., breed, feeding practices, or other raising and processing claims) and market themselves as "USDA Process Verified." Beef export verification is based on substantiation of conditions required by an importing company, of the exporting country, as verified by the USDA Quality System Assessment (QSA) program (e.g., beef export verification, Japan) (Smith et al. 2005).

1.11 HOW IP-*T*, TRACEABILITY, AND IPT SYSTEM PROGRAMS WORK: THE FUNDAMENTALS

1.11.1 IP-*T*

The global agricultural commodity system is being revolutionized as an increasing number of crops and livestock are being differentiated to ensure that their value or uniqueness is captured and maintained throughout the supply chain (Smyth and Phillips 2002). Again, IP refers to the trait(s) or credence attribute(s) of interest, whereas IP-*T* refers to the mechanism of software, documentation, tests, and audits that are used to insure that the IP trait(s) or attribute(s) are within tolerance or meet regulatory compliance.

The first product differentiation system is IP-*T* (in some literature it is called identity-preserved production and marketing, or IPPM), which has evolved over time in the grain and oilseed industry. Purchasers of raw products became more demanding about the quality and purity of the product they were purchasing, so the grain handling system gradually developed distinct channels to market the differing grades of grains and oilseeds. All grains and oilseeds are purchased by a grading system in today's marketplace; this grading system has premiums that rise as one moves from low to high grades. The relationship of premiums to differing grades for private market incentives is the defining feature of an IP system (Smyth and Phillips 2002).

IP-*T* systems have been initiated by the grain and oilseed industry to extract premiums from a marketplace that has expressed willingness to pay for an identifiable and marketable product trait or feature. An IP-*T* system is generally a closed-loop channel that facilitates the production and delivery of an assured quality by allowing identification of a commodity from the germplasm or breeding stock to the processed product on a retail shelf. Grain and oilseed IP-*T* systems are predominantly voluntary, private firm-based initiatives that range between systems that are loosely structured (e.g., malting barley) with high tolerance levels and those with rigid structures (e.g., non-GMO EU markets) with minimal tolerance levels. Firms operating in minimal tolerance systems achieve this by developing and adhering to strict protocols that specify production standards, provide for sampling, and ensure appropriate documentation to audit the flow of product* (Smyth and Phillips 2002).

Numerous IP-*T* systems operate around the world. Some extend only between the breeders and the wholesale market or processor, while others extend right up to the retailer. Their structure depends on the attribute being preserved. For instance, some novel oils, such as low linolenic oils that are more stable in fryers, only have value at the processing level, while others, such as high oleic oils, have health attributes that can be marketed to consumers. IP-*T* systems are important for providing information to consumers about the origin of a product, as those attributes are not visible or detectable in the product itself† (Smyth and Phillips 2002).

1.11.2 IP-*T* Segregation

The second product differentiation system, segregation, has frequently been applied incorrectly to the grading of different classes of grains and oilseeds to receive a higher price for the commodity than if it were allowed to be commingled. Segregation is a step between commodity processing (low value) and identity preserved (high value). It represents both a middle value and mid-level involvement of management to ensure its quality. Segregation systems have a formal structure and, in fact, can act as regulatory standards. Segregation differs from IP-*T* in that the focus of the system is not on capturing premiums, but rather on ensuring that potentially hazardous crops are prevented from entering supply chains that have products destined for human consumption. Segregation can be viewed as a regulatory tool that is required for variety approval and commercial release of grain and oilseed varieties that could enter the supply chain and create the potential for serious health hazards. Segregation systems can be developed as part of a variety registration process, in which government regulators use contract registration to ensure that certain novel varieties will not enter the handling system of like varieties. The private firm seeking registration of the novel variety has to demonstrate that there is a segregation system developed to ensure the containment of the variety‡ (Smyth and Phillips 2002).

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* A survey of the literature on IP shows that although there is growing discussion about IP systems, there are very few working definitions. It has been suggested that an IP system is a more stringent (and expensive) handling process and requires that strict separation, typically involving containerized shipping, is maintained at all times. IP lessens the need for additional testing as control of the commodity changes hands, and it lowers liability and risk of biotech and non-biotech commingling for growers and handlers (Smyth and Phillips 2002).

† The body of literature pertaining to aspects of IP is limited but is growing. Many of the works relate to IP systems relating to theoretical and operational uses of IP systems. Bullock, Desquilbet, and Nitsi (2000) and Bullock and Desquilbet (2001) discuss differentiation between GM and non-GM products, and Herrman, Boland, and Heishman (1999) examine the feasibility of wheat IP. Bender (2003) has released a series of papers on handling specialty corn and soybean crops, with costs being the focus, not the defining of the system used to handle the specialty crop. Additionally, Miranowski et al. (1999) offer some perspectives on the economics of IP, and Kalaitzandonakes, Maltsbarger, and Barnes (2001) provide a solid theoretical model for examining the cost of IP.

‡ The distinction between "IP" and "segregation" is often blurred, and a "strict segregation" system may be more precise than a loose IP system. The level of precision of the traceability system may also influence recordkeeping costs (Golan et al. 2004).

Segregation is focused on ensuring that the integrity of the special trait is not allowed to "adventitiously commingle" with other products destined for the food and feed supply chain. Production contracts are used by the private firms to ensure that the entire commodity being segregated is collected and that the producer retains no amount of seed* (Smyth and Phillips 2002).

1.11.2.1 Important Issue: Internal versus External Traceability

The Food Standards Agency of the European Community recognizes two levels of IP-*T* within the food industry. The first level, called "internal tracking," takes place within one link of the chain (Moe 1998). Considerable internal tracking already exists within the food industry, providing individual firms the ability to follow product logistics through their internal operations; however, only very limited information actually follows the product to the next step (Golan et al. 2004 and Pape 2006). In addition, the real difficulty in designing and implementing IP-*T* lies within the complexity of the second level, called "external (chain) tracking" (Moe 1998). Chain tracking, which provides information paths between individual entities throughout the entire food chain, cannot be achieved without considerable knowledge-based vertical integration and may entail any number of entities in the seafood industry including fishers, buyers, processor, wholesalers, transporters, and retailers † (Moe 1998 and Pape 2006).

When looking at IP-*T* systems it is important to distinguish between internal tracking and external (chain) tracking. Internal tracking is within a company or location that is under consideration. In terms of a product, it relates to the origin of materials, the processing history, and the distribution of the product after delivery. Chain or external tracking is, on the other hand, focused on the maintenance of product information from one link in the chain to the next. It describes which data are transmitted and received and how. Chain tracking is between companies and countries and depends on the presence of internal traceability in each link. In some literature the terms internal or external traceability are used instead of internal or external tracking (Moe 1998 and Pape 2006).

Most IP-*T* regulations focus primarily on external or chain tracking. Legislation demands that each producer has control over input ingredients and is able to identify from whom they bought the raw material and to whom they delivered the finished products. This is a major gap within the notion of food and ingredient accountability.

* Buffer zones are required for segregation systems as a preventative measure for reducing crosspollination. Producers may also have restrictions placed on what crop varieties are allowed to be grown the following year on fields that produced segregated crops. Premiums are available in the short and long term to ensure that product supply is maintained.

† Two important motives for the formation and coordination of information in vertical supply chains are to manage liability associated with adulteration or contamination and to identify and preserve quality traits. Traceability systems can be defined by these motives. Segregation systems attempt to separate batches of food and ingredients from each other during processing, whereas IP-*T* systems identify the source and nature of each batch, requiring considerable information to guarantee that the traits and qualities of the product are maintained throughout the supply chain. The type of system to be used will depend on what the producers want to accomplish and how much information they want to make available to other firms in the supply chain. Information on products and production practices must remain in the control of the entity responsible for these processes (Golan et al. 2004).

For example, a processor should be able to document all of the different input ingredients as they arrive on their loading dock for use. Many loads of flour may arrive from different sources and be poured into one of several bins. Over time, as one bin empties, the flour from another bin (from still other sources) will be introduced into the process. Regarding rules that processors must follow, the processor should also be able to document, as product leaves its loading dock for its next destination, what ingredients are in the product. Unfortunately, internal tracking is often lacking in accounting for mixing of in-house bins (because bins are constantly being filled, and because product is continuously used in production). This has been the main focus during the past decade and today there exist several standards and/or solutions that will solve the internal traceability issues (Moe 1998 and Pape 2006).

1.11.2.2 Internal Tracking (In-House, Processor)

Many advantages can accrue from having internal tracking. A minimum of internal tracking, being able to track the raw material that went into a product, is in the interest of most food manufacturers. Establishing internal tracking may be easy enough for individual batch processing; however, for continuous or semicontinuous processing it can be very difficult. Under such conditions the ideal traceable resource unit (TRU) can be very small and therefore many food processors do not have tracking down to the ideal TRU. Instead they have a sort of "sufficient" tracking, in which products processed within a period of time are known to come from a certain raw material batch, with some mixing at both ends. However, only an internal tracking system coming close to tracing the ideal TRU can be used as a grid for combining data from process control, quality management, and other management systems (Moe 1998 and Pape 2006).

Achieving external or chain tracking requires comprehensive planning during the initial stages of development, particularly when addressing the three issues most crucial to the success of any traceability system. These include compatibility, meaning it must be possible to track products from one entity to another;* data standardization, or compatible data transmission protocols and computer applications to integrate knowledge-based operations, which may include product handling and processes, including transformation, value addition, packaging, transport, and storage; and the definition of a TRU. Defining a TRU may be one of the most difficult steps involved in the design of a traceability system† (see Appendix A regarding IP-*T* systems at seed production, processing, and retail stages).

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* This requires that all entities within the chain are able to communicate and transmit data efficiently. Having the ability to transmit and receive data does not, in itself, ensure traceability; it only provides a means. Rapid advances in information technology and increased compatibility between available operating systems have provided the necessary tools to improve knowledge-based vertical integration.

† A TRU is simply defined as a unit of trade, such as a whole fish or a batch of fish at the initial stage. However, this will invariably change during processing because new TRUs are assigned at each step within the food chain. The initial TRU must follow each fish or lot, through all steps of processing, distribution, and retail. This process can become very complicated, especially during processing, and it may be difficult to keep from mixing fish from several batches, especially when processing may include portioning, additional ingredients, processes, storage, and transportation. Mixing of batches can occur between resource units, which may cause problems in identifying individual batches. Each

1.11.2.3 Quality Management

IP-*T* is also an essential subsystem of quality management. The development of advanced internal IP-*T* systems can, however, also be spurred by the search for improving the efficiency of data collection, plant control, and quality assurance. That search has resulted in an increasing interest in coupling data from more than one control or management system, which in turn, requires that a traceability system with a high degree of detail be established. Traceability is also a system in itself and its establishment should be given proper attention and suited to actual needs using a systematic approach. To do this well requires awareness of the various features of traceability that are addressed in this book (Moe 1998).

1.11.3 IP-*T* Systems

According to Golan, Krissoff, and Kuchler (2004),* an IP-*T* system can be split into two elements; namely, the routes of the product and the extent of tracking desired or willing to be paid for. Routes describe the path along which, and the means by which, products can be identified throughout the manufacturing, distribution, and retail system. Extent defines the scope of tracking. This is elaborated below. The descriptors *depth*, *breadth*, and *precision* highlighted in Golan works will be used to describe overall IPT concepts.

- ***Depth*** is how far back or forward the system tracks the relevant information. For example, an IPT system for decaffeinated coffee would extend back only to the processing stage. An IPT system for fair-trade coffee would only extend to information on price and terms of trade between coffee growers and processors. An IPT system for fair wages would extend to harvest; for shade grown, to cultivation; and for non-genetically engineered, to the bean or seed. For food safety, the depth of the traceability system depends on where hazards and remedies can enter the food production chain. For some health hazards such as BSE, ensuring food safety requires establishing safety measures at the farm. For other health hazards, such as food-borne pathogens, firms may need to establish several critical control points along the entire production and distribution chain. The key here is to know what traits/attributes are desired and/or what safety level is needed for who or what (e.g., for labors, processors, consumers, environment, animals, etc.) (Golan, Krissoff, and Kuchler 2004).

(Continued)
firm must develop a system of assigning new TRUs during processing, distribution, and retail (Moe 1998 and Pape 2006).

* Golan, Krissoff, and Kuchler have written extensively on food issues such IPT systems. Her work with others in *Traceability in the U.S. Food Supply: Economic Theory and Industry Studies* and *Food Traceability One Ingredient in a Safe and Efficient Food Supply* is the basis for greater comprehension of how IPT regulations and pragmatic realities of how these regulations are used serve as a standard in clarity of understanding these topics. I wish to express my appreciation for their work and how it has added to this research paper. The portion of IP-*T* that addresses breadth, depth, and precision, is borrowed, shortened, and modified from her works.

- ***Breadth*** describes the amount of information collected. A recordkeeping system cataloging all of a food's attributes would be enormous, unnecessary, and expensive. Take, for example, a cup of coffee. The beans could come from any number of countries, be grown with numerous pesticides or just a few, be grown on huge corporate organic farms or small family-run conventional farms, be harvested by children or by machines, be stored in hygienic or pest-infested facilities, and be decaffeinated using a chemical solvent or hot water. Few, if any, producers or consumers would be interested in all this information. The breadth of most IPT systems would exclude some of these attributes (Golan, Krissoff, and Kuchler 2004).
- ***Precision*** reflects the degree of assurance with which the IPT system can pinpoint a particular food product's movement or characteristics.* In some cases, the objectives of the system will dictate a precise system, whereas for other objectives a less precise system will suffice. For more traditional systems, such as in bulk grain markets, a less precise system of traceability from the elevator back to a handful of farms is usually sufficient because the elevator serves as a key quality control point for the grain supply chain. Elevators clean and sort deliveries by variety and quality (e.g., protein level). Elevators then blend shipments to achieve a homogeneous quality and to meet sanitation and quality standards. Once blended, only the new grading information is relevant; there is no need to track the grain back to the farm to control for quality problems. Strict tracking and segregation by farm would prevent the ability of elevators to mix shipments for homogeneous product† (Golan, Krissoff, and Kuchler 2004).

1.11.4 What Does an IPT Chain Do?

Firms have three primary objectives in using IPT systems: (1) improve supply management, (2) facilitate trace-back for food safety and quality, and (3) differentiate and market foods with subtle or undetectable quality attributes. With regards to business, the benefits associated with these objectives include lower cost distribution systems, reduced recall expenses, and expanded sales of products with attributes that are difficult to discern. In every case, the benefits of IPT translate into larger net revenues for the firm. These benefits are driving the widespread development of traceability systems across the U.S. food supply chain (Golan, Krissoff, and Kuchler 2004).

* Precision in trace-back to the farm declines the further one goes down the production chain. As grain is funneled from a wider geographic area, it is more difficult to pinpoint from where and from whom the commodities came. Traceability at the port elevator level typically extends only back to the country or subterminal elevator (Golan, Krissoff, and Kuchler 2004).

† When farmers deliver their crops to local elevators, they are given receipts that indicate the commodity sold, its weight, price received, time of purchase, and any premiums or discounts for quality factors such as extra moisture, damage, pests, or dockage (easily removable foreign material). Country elevators keep this information, thus establishing a recordkeeping link from the product in an elevator at a point in time to the farmers who supplied the product. An elevator operator knows the farmers that delivered grain and oilseeds at that location and the geographic area from which they came. This is the minimum level of IPT that is required by the USDA (Golan, Krissoff, and Kuchler 2004).

1.11.4.1 Third Parties: Options to Enhance IPT

In cases in which markets do not supply enough traceability for product differentiation, individual firms and industry groups have developed systems for policing and advertising the authenticity of credence claims. Third-party safety/quality auditors are at the heart of these efforts. These auditors provide consumers with verification that traceability systems exist to substantiate credence claims. For example, auditors from Food Alliance, a nonprofit organization, certify foods grown with a specific set of sustainable agricultural practices. Many buyers, including many restaurants and some grocery stores, now require their suppliers to establish IPT systems and to verify, often through third-party certification, that such systems are in compliance. The growth of third-party standards and certifying agencies is helping push the whole food industry, not just those firms that employ third-party auditors, toward documented, verifiable traceability systems (Golan, Krissoff, and Kuchler 2004).

For some crops, farmers may be asked to submit their shipments for testing. For example, the oil content of corn and the protein level in wheat are routinely tested. Tests may be performed by the elevator or by independent third-party verifiers. Elevators usually keep records of test results, including the identity of the farms that sold the commodities to them. For some specialty crops, buyers may simply require farmers to certify that the crops are as specified. This was the case early in the development of differentiated markets for non-genetically engineered crops (Golan et al. 2004).

Most, if not all, third-party food-safety/quality certifiers such as the Swiss-based Société Générale de Surveillance (SGS) and the American Institute of Baking (AIB) recognize traceability as the centerpiece of a firm's safety management system. AIB's standard food safety audit specifies several very specific activities* (American Institute of Baking 2003 and Golan et al. 2004).

According to Golan, Krissoff, and Kuchler (2004), electronic systems for tracking inventory, purchases, production, and sales have become an integral part of doing business in the United States. A few big retailers such as Wal-Mart and Target have even created proprietary supply-chain information systems that they require their suppliers to adopt. In addition to private systems, U.S. firms may also use industry-standard coding systems such as UPC codes. These systems are not confined to packaged products. The food industry has developed several complex coding systems to track the flow of raw agricultural inputs to the products on grocery store shelves. These systems help to create a supply management system stretching from the farm to the retailer.

* Third-party standards and certifying agencies are used across the food industry. In 2002, AIB audited 5,954 food facilities in the United States and was slated to audit 6,697 in 2003; SGS expected to perform over 1,000 U.S. food safety audits in 2003; and ISO management standards are implemented by more than 430,000 organizations in 158 countries (ISO website). Food sectors using third-party verifiers cover the spectrum from spices and seasoning to fruit and vegetables to meat and seafood to bakery products and dough. The growth of third-party standards and certifying agencies is helping to push the whole food industry, not just those firms that use third-party auditors, toward documented, verifiable traceability systems (Golan, Krissoff, and Kuchler 2004).

1.11.4.2 Risk Accumulates

The benefits of precise tracking and tracing for food safety and quality control are greater with the increased likelihood and cost of safety or quality failures. Where the likelihood and cost of failure are high, manufacturers have large financial incentives to reduce the size of the standard recall lot and to adopt a more precise traceability system. The benefits of traceability are also likely to be high if other options for safety control are few (Golan et al. 2004).

1.11.4.3 Traceability Chain (Back-tracing)

Another benefit of IPT systems is that they may help firms establish the extent of their liability in cases of food safety failure and potentially shift liability to others in the supply chain (see Chapter 12 regarding recalls and liability issues) If a firm can produce documentation to establish that the safety failure did not occur in its plant, then it may be able to protect itself from liability or other negative consequences (Golan et al. 2004).

Despite the important role safety plays within traceability systems, it is only one element of a firm's overall safety/quality control system. In and of themselves, traceability systems do not produce safer or high-quality products or determine liability. Traceability systems provide information, looking backward, about whether control points in the production or supply chain were operating correctly or not. In cases where markets do not supply enough traceability for food safety trace-back, several industry groups have developed food safety and trace-back standards. For example, the California cantaloupe industry has incorporated traceability requirements in their marketing order to monitor food safety practices. In addition, buyers in every sector are increasingly relying on contracting, vertical integration, or associations to improve product traceability and facilitate the verification of safety and quality attributes. Many hog operations are now integrated by ownership or contractually connected to slaughtering firms. As a result, identification by herd or batch is much easier today than 50 years ago (Golan, Krissoff, and Kuchler 2004).

1.11.5 Traceability

Traceability (back-tracing) can also be considered another product differentiation system commonly used in the food industry. Retail products found with unacceptable bacteria levels or intolerable levels of pesticide or chemical residues need to be quickly and completely removed from store shelves. Traceability systems allow for retailers and the supply chain to identify the source of contamination and thereby initiate procedures to remedy the situation. The key focus of traceability is on food safety. Additionally, the focus for developing traceability systems for new sectors of the marketplace has shifted to include extracting premiums from products that possess traits of value. Extracting market premiums could never be the driver for developing a traceability system. In and of themselves, traceability systems do not motivate quality, they simply trace it (Smyth and Phillips 2002).

Various traceability systems have been established in Europe, North America, and elsewhere. In Canada, traceability was developed in conjunction with a quality assurance (QA) system to reassure export markets about the quality of Canadian beef products.* In a similar QA effort, the Canadian grain and oilseed industries conducted a 2-year pilot project in 2002 and 2003 to evaluate the costs and benefits of an on-farm HACCP-based traceability system (Smyth and Phillips 2002).

Traceability (or retrospective analysis) is required to recall what has already occurred and, in use, traceability works backward. This means that the recordings concerning the TRU must be designed from the viewpoint that they will be retrospectively interrogated. Furthermore, a stable, accessible record system is essential (Moe 1998).

1.11.5.1 Advantages of Traceability

Traceability offers the following advantages:

- Establishes the basis for efficient recall procedures to minimize losses.
- Information about the raw material can be used for better quality and process control.
- Avoids unnecessary repetition of measurements in two or more successive steps.
- Improves incentive for maintaining inherent quality of raw materials.
- Makes possible the marketing of special raw material or product features.
- Meets current and possible future requirements (e.g., confirming country of origin).

Most food processing companies establish end-product traceability to secure efficient product recall procedures. Product recall systems only require traceability in part of the chain from the production step to the consumer. However, if the problem stems from the supply of raw material, traceability back to the supplier improves the possibility of either correcting faults, avoiding reoccurrence, or placing the responsibility there. Recall systems can be established on a minimum of traceability information (e.g., production date); however, the more subdescriptors that are included (e.g., production time, batch number, production conditions) the more focused the product recall can be, thereby minimizing loss of money and reputation (Moe 1998).

1.11.5.2 Combining Forward-Tracking Systems with Back-Tracing Systems—IPT

IPT can be used in four distinct contexts, each with a different implied sense.

1. Product: IPT may relate materials, their origin, processing history, and their distribution and location after delivery.
2. Data: IPT relates calculations and data generated throughout the quality loop, sometimes back to the requirements for quality.

* In this case however, it should be noted that this system has been met with great resistance at the farm level, because producers do not want to allow government regulators onto their farms or provide regulators with any sensitive farm information.

3. Calibration: IPT relates measuring equipment to national or international standards, primary standards, basic physical constants or properties, or reference materials.
4. Software and programming: IPT relates design and implementation back to the requirements for a system.

Product and data cover the fundamental concepts included in independent traceability and tracking systems relating to products and their processing (Moe 1998). These important issues are somewhat neglected in the literature on food processing and are therefore the subject of this book. Calibrating measuring equipment using standards that are trackable and traceable to national or international standards is essential to all food business to provide a common base for assessment of product quality and performance in accordance with specification. This is well discussed in the literature and Chapter 8. The IPT system is explained in greater detail in Chapter 10.

1.11.5.3 Overall Supply Chain IPT Management

In addition to traceability as a food safety mechanism, it is also crucial for providing access to new categories of products. Many markets have demanded documentation regarding product composition before allowing market access. Consumer information is fundamental for traceability systems, because they are designed to increase information regarding food safety to consumers. Information is also provided back up the supply chain to regulators and processors. Labeling is important to traceability to ensure high-quality standards and allow consumers to identify with this feature. In this way, market premiums may be available for products that show evidence of continuous traceability.

1.12 SUMMARY OF CHAPTERS

Part I consists of Chapter 1, "Introduction to Identity Preservation and Traceability;" Chapter 2, "IPT History;" and Chapter 3, "Overview of IPT System Components, Theory, and Design." Part II (Chapters 4–6) provides examples of official seed agencies, industry programs, and standards including U.S., Canadian, EU, international, organic, regional, and religious standards. Part III includes Chapters 7 and 8, a sampling and explanation of auditors and laboratories. Part IV (Chapters 9–12), reviews domestic and foreign policy and advisory organizations, software providers, IPT process facilitators, and information about food recalls and insurance. Part V (Chapters 13 and 14) provides examples of a spreadsheet and questionnaire. The last portion of this work contains the conclusion; appendices; related products, services, and organizations; glossary of terms; directory of resources; and bibliography.

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