CAST® Issue Paper Number 56 October 2015

Process Labeling of Food: Consumer Behavior, the Agricultural Sector, and Policy Recommendations

Process labels can effectively bridge the informational gap between producers and consumers, but such labeling often has serious unintentional consequences. (Background image from Joshua Rainey Photography/Shutterstock; Foreground image from Matthew Cole/Shutterstock [adapted].)

Abstract

The simple phrase "You are what you eat" is commonly taught to children and then repeated throughout one's life. This phrase speaks to the intimate connection between individuals' food choices and their health—and even their personal identity. Yet most modern consumers rarely grow their own food, which means that what people "are" is a bit out of their control. Given today's predominantly global food supply chain, consumers have little ability to observe directly the production process that created the food they eat.

Consumers are frequently exposed to labels communicating specific processing aspects of food production, such as Certified Organic, Rainforest Alliance Certified, rbST free, Fair Trade, and Free of Genetically Modified Organisms. At the root of this phenomenon are the desires for individual control and a diffuse distrust in the safety and health of the food produced by modern agriculture. These desires are paired with concerns about the ethical, social, and environmental consequences of food production. Under appropriate third-party or governmental oversight, these "process labels" can effectively bridge the informational gap between producers and consumers, satisfy consumer demand for broader and more stringent quality assurance criteria, and ultimately create value for both consumers and producers. Despite these potential benefits, process labeling often has serious unintentional consequences. For instance, labeling the benefits of a process for a

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new niche product can implicitly cast the conventionally produced product in a negative light. This type of stigmatization of the conventional product can be particularly problematic in situations in which no scientific evidence exists that the food produced with the conventional process causes harm, or even that it is compositionally any different. Potential unintended consequences of process labeling are increasing food prices, inducing unsubstantiated quality expectations for the newly labeled products, and stunting scientific and technological advances in agriculture.

Advances in agricultural science and technology have proved beneficial to producers and consumers alike and will inevitably be needed to improve the conditions of the poor in the United States and throughout the world. This CAST Issue Paper examines what is known regarding consumer reaction to process labels, identifies the legal framework for process labeling, and ultimately provides policy recommendations that highlight when process labeling is beneficial or harmful to the agricultural sector and the people who eat the food it produces. Specifically, we recommend that mandatory labeling occur only in situations in which the product has been scientifically demonstrated to harm human health. Likewise, governments should not impose bans on process labels because this approach goes against the general desire of consumers to know about and have control over the food they are eating and it can undermine consumer trust of the agricultural sector. We believe that a prudent approach is to encourage voluntary process labeling under the conditions that these labels are true and scientifically verifiable and that, when the labels claim a product "contains" or is "free of" a certain production-related process, the product should also include a label stating the current scientific consensus regarding the importance of this attribute.

Introduction

In several recent cases, food production technologies approved by the U.S. Food and Drug Administration (FDA) have been under intense consumer scrutiny after being the object of negative media and public pressure. For instance, in 2012 there was considerable controversy over the decision to not label meat products containing lean finely textured beef (LFTB), also referred to as "pink slime" after ABC News reported on the presence of LFTB in a significant number of meat products. Consumers felt misinformed and deceived by the concealment of LFTB's presence in meat products. The negative consumer response was swift, resulting in a decrease in demand for any meat products containing LFTB and a response from companies like McDonald's, Taco Bell, and Burger King to ban the use of LFTB in any of their products (Eckley and McEowen 2012). With the decrease in demand, LFTB producers such as Beef Products Inc. faced plant closures and production fell by 1.6 million pounds, shifting the company's profit from $2.3 million per week to $583,000 per week (Engber 2012). Other examples include the use of antibiotics in chicken, genetically modified organisms (GMOs),[1] irradiation, and recombinant bovine somatotropin (rbST) in milk. In such instances, process labels have been advocated as the ideal solution because the ultimate decision is left in the hands of consumers.

The distance between the consumer and producer in today's global food system poses obstacles for effective communication and establishment of trust. Much of the literature related to product labeling focuses on the problem of asymmetric information: producers are aware of the quality of what they sell, whereas consumers generally are not (Nelson 1970). A classic example of asymmetric information occurs between used car salespeople and potential buyers. Because the salesperson has more information about the car quality and the used car market, buyers' trust tends to be low.[2] A common response to situations with asymmetric information is the provision of "independent" assessments by experts, such as getting a third-party mechanic to assess the condition of a used car. Alternatively, government regulation can help ensure quality through enactment of policies such as "lemon laws." For instance, the

[1] For more information about the labeling of genetically engineered foods, see CAST (2014).

[2] A 2013 Gallup poll revealed that only 9% of Americans rated car salespeople "very high" or "high" when it came to honesty and ethical standards (Davidsen 2013).

public generally has a high level of trust for consuming FDA-approved pharmaceutical products, even though few consumers understand the science behind the drugs or understand their manufacturing process (APA 2014; Davidsen 2013; Manchanda et al. 2005; USFDA 2013).

When product quality and safety is uncertain, consumers can search for information they deem important; but when information about a food product is too costly or difficult to obtain, consumers can find it difficult to align food choices with their individual preferences. Further complicating matters is the fact that many important food characteristics, such as taste, can be assessed only after consuming the food (hereafter referred to as "experience attributes") (Nelson 1970), and many claims, such as "contains omega-3" or "extra virgin" olive oil, cannot be directly verified by consumers (hereafter referred to as "credence attributes") (Darby and Karni 1973).

Directly observing the food production process is even more difficult. In such situations of asymmetric information, consumer behavior is expected to change if additional information becomes available. From a policymaking standpoint, the principal role of food labels is therefore to disseminate accurate information at the point of sale, where most of the food choices are made, and thereby inform consumer choice. As pointed out by Caswell and Mojduszka (1996), labels can facilitate consumer choice by transforming credence and experience attributes into searchable characteristics, thereby decreasing the information gap between consumers and producers.

Concerns related to asymmetric information in food have led to a variety of regulations associated with food labeling. Although these policies frequently are related to food safety and nutrition, some consumers are also interested in information related to the production processes involved in producing the food and have advocated for on-package process labels. As the examples in Table 1 document, a wide variety of process labels currently exists in the market, describing either a single aspect of a production process or a set of encoded practices.[3]

Food labels can create value for consumers when they provide information relevant to their decision process and opportunities for producers whenever product differentiation opens new market segments. Caswell and Padberg (1992) suggest that labels can provide a solution to markets with imperfect information on food safety, and voluntary labels can provide an efficient quality signaling mechanism for markets with limited governmental oversight (Caswell and Mojduszka 1996).

Although the recent proliferation of production-oriented labels may seem like a new phenomenon, it is good to remember that process labeling actually has a long history. Derived from the Torah and the Talmud, the kosher dietary laws identify which foods are "fit or proper" for Jews (Regenstein, Chaudry, and Regenstein 2003). Kosher laws outline various prohibitions of certain food products and food processes. Similarly, the halal laws originating from the Quran and the Hadith specify which foods are "lawful" for Muslims and prohibit the consumption of certain meat products produced using prohibited processes (Regenstein, Chaudry, and Regenstein 2003).

The fact that marketers use process labels as a way of distinguishing and creating a unique brand for their products with the goal of increasing sales and profits should not be surprising. Consumers now experience an ever-widening array of labels on their food, which raises many related questions. Which consumers are changing their behavior in response to process labeling, and why? Are these consumer changes temporary or long lasting? Should firms be required to label how their food was produced or should these labels be voluntary? How do changes in consumer behavior impact the food sector, the price of food, and the general role of science and technology in the food system? Should labels only be used in situations in which there are proven health risks and environmental impacts? Are there unintended consequences associated with process labels, and, if so, are there alternative ways of delivering this information? This paper seeks to answer these questions and provide policy recommendations that strike a science-based middle ground that can work for both consumers and producers.

Historical Success of Science and Technology in Food Production

The global population is approximately 7.2 billion (U.S. Census Bureau

[3] This paper discusses the issues surrounding labels providing information directly related to the food production process. While many other types of food labels exist, including nutritional information (e.g., ingredients, nutrition facts, serving size), labor practices, and product origin information (e.g., country and other geographical indications), they are generally not considered in this paper. Likewise, the authors do not discuss the public finances issues related to food labeling (see Crespi and Marette [2005] for a summary related to ecolabels).

Table 1. Examples of food process labels

Single Practice	Set of Practices
Antibiotic Free	American Humane Certified
Cage-free Eggs	Animal Welfare Approved
"Contains"/"Free of" Genetically Engineered Product	Bird Friendly
Dolphin-safe Tuna	Certified Humane
Pasture-raised Eggs	Extra Virgin
Radura (Irradiated)	Fair Trade
rbST-free Milk	Free Range
Shade-grown Coffee	Halal
Vine-ripened Tomatoes	Humanely Raised
	Kosher
	Organic
	Rainforest Alliance Certified
	Salmon Safe
	Sustainably Produced

2014), and a large number of these people live without adequate food supplies. One out of every nine people in the world is malnourished (World Food Programme 2014), and in the United States approximately one out of every seven people is food insecure (USDA–ERS 2014).

Although these are certainly serious problems, what is often overlooked is the remarkable fact that the world population has increased approximately 500%, from 1.2 billion people in 1850 to 7.2 billion in 2015 (UN–DESA 1999); and in the process of adding 6 billion more mouths to feed, the percentage of those who have inadequate food supplies has generally declined (IUNS 2012). The benefits accruing from applying science and technology to the food system make up a major part of the reason the human population was able to increase so dramatically in the past 150 years. For instance, average corn grain yields in the United States have increased by nearly 700% since the 1860s (USDA–NASS 2014), and once-common syndromes associated with poor diets (e.g., scurvy, pellagra) have virtually disappeared from developed countries (Ginnaio 2011).

Production of other food staples has also significantly increased throughout the world, all without imposing a significant growth in the number of acres of cropland under cultivation (Lanzini 2006). Additionally, the real price of food has generally been declining. Currently, the average U.S. household spends only approximately 11% of its income on food compared to approximately 42% in 1900 (Thompson 2013).

For farmers, scientists, and others in the food industry, this impressive track record of success in applying science and technology to the food system is a proud history. Yet some consumers do not share this enthusiasm for these accomplishments, and an increasing number of people express strong concerns about food products associated with agricultural science and technology (e.g., biotechnologies). For instance, the purchase of organic foods has increased by $17 billion since 1997 (Vermeer, Clemen, and Michalko 2010) and the U.S. organic market was estimated to be worth $35 billion in 2014 (USDA–ERS 2014). Even though price premiums for organic food have remained high (USDA–ERS 2015), certified organic products have experienced double-digit growth over the past decade and can be found in a wide variety of retail settings.

The market for foods with environmental process labels (e.g., "green" and "eco") has also experienced strong growth both in the United States and throughout the world. Currently, there are more than 450 ecolabels in nearly 200 countries related to more than 25 industry sectors (Ecolabel Index 2015). In addition to food, many of the labels apply to the personal care, electronics, textile, and apparel sectors (Vermeer, Clemen, and Michalko 2010). In the agriculture sector, Certified Organic and Rainforest Alliance Certified are two prominent process labels. The Rainforest Alliance Certified logo covers a wide variety of products produced in tropical countries, and the certification process has been adopted by large companies such as Dole, Chiquita, Heinz, Walmart, and IKEA (Vermeer, Clemen, and Michalko 2010).

What explains this rise in demand for food with process labels? Returning to the concept of asymmetric information, food production has seen dramatic change over the past 50 years, and in most cases these changes have occurred outside of the direct purview of consumers. During this same time period, however, a number of new health and environmental concerns have risen in the public discourse that may be related to the food system.

News stories are released on a regular basis about negative health trends and associated claims related to current food consumption and production processes (Alderman 2010; IUNS 2012). Examples include the following: (1) peanut allergies in children have risen by approximately 250% since 1997 (Brody 2014); (2) globally, the diagnosis of autism has increased "twentyfold to thirtyfold" since the late 1960s (CDC 2014); (3) large increases have been shown in the number of children diagnosed with attention deficit hyperactivity disorder (Schwarz and Cohen 2013) and autoimmune disorders, such as celiac disease and diabetes (Rattue 2012; Stampler 2014); (4) girls in the United States are currently reaching puberty significantly faster than previous generations—an average of one year earlier for Caucasian girls and two years earlier for African American girls (Brody 1999; Weil 2012).

Concerns have also been raised about the impact of modern farming techniques on the environment, such as the decline in the populations of honey bees (Kluser et al. 2010) and monarch butterflies (Main 2014) as well as negative impacts on water quality (USEPA 2015). There is no consensus that these health and environmental issues are due to the way food is currently produced. In fact, many of these issues may really be the result of more careful diagnosis, improved data collection, or just changes in people's diet or other changes in the environment.

These health trends and claims, however, whether accurate or not, can sow seeds of doubt in consumers regarding the food they are eating, especially when they feel like they have lost control over the choices offered by the food system. In situations in which there is uncertainty regarding the cause of the problem, it is common that lay people's perceptions of the risks and the problem's origin will differ from the dominant views of the scientific community (Messer et al. 2006). Additionally, Frewer and colleagues (1997) note that new technologies may be rejected if the resulting risks and benefits affect interested parties differently. If consumers perceive that producers reap all or the majority of the benefits while consumers shoulder the possible risks, there will likely be resistance toward the new technology. Information provided by experts, even from a trusted source, is short lived (Frewer et al. 1997), and in situations in which both scientific experts' opinions and more general negative unscientific information is provided to consumers, the negative information tends to dominate (Hayes, Fox, and Shogren 2002; Liaukonyte et al. 2013).

Thus, when presented with this list of health and environmental concerns and their potential links to modern agricultural procedures, it should not be surprising that some consumers are demanding more information—via labeling—about how their food is produced (Coppola and Verneau 2014). In some cases, the provision of information via labeling creates new market opportunities for producers (e.g., organic) and increases choices for consumers. In other instances, however, such win-win outcomes fail to materialize. In the next sections of this paper, the authors summarize the general legal and historic framework under which process labels have evolved and then conduct a systematic review of the large body of consumer behavior literature studying the effects of process labels. This background provides the basis and justification for the policy recommendations offered at the conclusion of the paper.

Legal History and Framework on Food Labeling

There are numerous federal and state laws requiring the labeling of food products, including the following:

- Federal Meat Inspection Act (U.S. Congress 2006a)
- Poultry Products Inspection Act (U.S. Congress 2006b)
- Egg Products Inspection Act (U.S. Congress 2006c)
- Federal Food, Drug and Cosmetic Act (FDCA) (U.S. Congress 2006d)
- Fair Packaging and Labeling Act (U.S. Congress 2006e)
- Federal Trade Commission Act (FTCA) (U.S. Congress 2006f)

Whereas an in-depth discussion of these laws is beyond the scope of this paper, these labeling requirements are intended to inform consumers about what they are purchasing and consuming, prevent consumer deception, assist consumers in making value comparisons between goods, and prevent injury to the public's health from the sale of misbranded foods.

In addition to the mandatory food labeling laws referenced earlier, marketers are increasingly using process labels to distinguish food products. Essentially, this type of marketing is intended to use terms or endorsements, such as those referenced in Table 1, that food producers believe appeal to a large consumer base and give the product a competitive advantage in the market. Although the use of such terms or endorsements may be an effective way to stand out in the market, it (whether expressly or by implication) risks scrutiny from regulators, challenges from competitors, and even potential civil liability. In the United States, these claims are regulated by key provisions of the Federal Trade Commission's (FTC's) *Guides for the Use of Environmental Marketing Claims* (FTC 2013) and the recent updates to these guides.

Regulatory Framework

Process marketing claims are subject to regulation through a combination of federal and state advertising and consumer protection laws. The FTC is the primary federal agency responsible for regulating marketing and advertising claims and ensuring that these advertising claims comply with the FTCA.

In 1992, the FTC established national standards for these types of marketing claims. This guidance was revised in 1998 and updated in October 2012. Although this guidance document is not law or a set of administrative rules, it provides instruction on how the FTC should evaluate process marketing claims and how it interprets its authority to regulate unfair or deceptive acts or practices under Section 5 of the FTCA when examining these marketing claims (FTC 2013).

Other federal agencies may also regulate certain marketing claims for products or services that these agencies have the authority to regulate. For example, the FDA and the U.S. Department of Agriculture (USDA) apply additional regulation and oversight to the extent that certain food products are marketed as being "natural" (USDA–FSIS 2009; USFDA 2008) or "organic" (USDA–AMS 2005). Additionally, the FDA requires irradiated foods to bear the international symbol for irradiation, referred to as the Radura symbol, along with the statement "Treated with radiation" or "Treated by irradiation" on the food label.

FTC Guidance Document Pertaining to Process Marketing Claims

The FTC Guidance (*Guides for the Use of Environmental Marketing Claims*) addresses how the FTC treats certain advertising and marketing practices under the FTCA, including the use of certain terms or endorsements such as "natural," "free of," or "pasture raised" (FTC 2013). In addition to outlining general principles that apply to the use of such terms or endorsements, the Guidance provides information on making specific types of claims regarding the attributes of a product, package, or service. In 2012, the FTC released its latest revisions to the Guidance in light of the increased use of terms or endorsements not previously covered by the Guidance. The FTC applies the Guidance to all forms of marketing, including labeling, advertising, and promotional materials; all expressed and implied claims, including claims made through words, symbols, emblems, logos, depictions, brand names, or any other means; products, packages, and services; and marketing through any means of communication, including the Internet or e-mail. The Guidance sets out four general principles that apply to such marketing claims:

1. First, claims must make clear, prominent, and understandable statements, including any qualifications or disclosures required to avoid misleading consumers. The FTC evaluates, among other things, whether or not clear language has been used, what type size is used for the qualification or disclosure and how it compares to the type size used for the rest of the marketing claim, how close the qualification or disclosure is to the marketing claim, and whether or not there are any contrary claims.
2. Second, the consumer should be able to easily determine whether or not any marketing claim applies to a company's product or service, product packaging, or business operations, such as manufacturing or shipping.

3. Third, a claim should not overstate the environmental attribute or benefit.
4. Finally, producers should ensure that the basis for any comparative claims is clear by avoiding use of open-ended comparative claims. Comparative claims should clearly identify the basis of the comparison, such as a comparison to either a specific competitor's product or the company's product from a prior year.

As with any other form of marketing or advertising, marketers should make sure that their marketing claims are supported by adequate substantiation. Every claim made in an advertisement about an objective quality, feature, or attribute of a product or service, whether express or implied, must be substantiated. If the marketer cannot adequately substantiate the claim, the FTC or a state attorney general may assert that the claim is deceptive.

Importantly, the Guidance also provides regulatory guidance for specific types of claims. For example, the Guidance provides instruction for marketing of products with claims that a product is "free of" a certain component. A truthful claim that a product, package, or service is free of, or does not contain or use, a substance may still be deceptive if it contains or uses substances that pose the same or similar environmental risks as the substance that is not present. Similarly, an otherwise truthful claim may also still be deceptive if it contains or uses a substance that has never been associated with the product category.

There are certain claims, however, for which the FTC has declined to propose definitions or specific guidance. These claims include "sustainable," "natural," and "organic." As discussed previously, however, there are other regulatory entities, such as the USDA, that have laws and rules in place that govern these claims. Additionally, there are some states that have weighed in on the use of such claims.

'Natural' Food Claims

Foods are commonly labeled as natural or containing natural ingredients. As the FDA has noted, however, it can be difficult to define when a food product is "natural" because the food has probably been processed and is no longer the product of the earth. Despite this potential confusion, the FDA has declined to adopt a formal policy defining the term natural when used on food labels (*Cox v. Gruma Corp*. 2014). Instead, the FDA has adopted an informal, nonbinding policy in which the agency has not objected to the use of the term natural to describe food if the food does not contain added color, artificial flavors, or synthetic substances.

The FDA has stated that it has not adopted a formal definition of "natural" for foods because doing so would require the agency to engage in rulemaking under the Administrative Procedure Act, which is a lengthy process that would divert the agency's resources from other priorities (USFDA 1993). The FDA has also stated that, given the numerous factors it would have to consider—including consumer preferences and beliefs, the vast array of modern food production technologies, and the various food processing methods—there is no assurance that a rulemaking process would change the current policy or lead to a formal definition (USFDA 1993).

Therefore, the FDA and courts considering consumer complaints—including claims for false advertising, unfair trade practices, consumer protection, and fraud—evaluate "natural" claims on a case-by-case basis.

Labeling Organic Food

Federal law establishes national standards for organic production and food labeling. A party cannot sell or label an agricultural product as organic unless it is produced and handled in accordance with the Organic Foods Production Act (U.S. Congress 2006g). To be sold or labeled as organic, in general, a product must have been produced and handled without the use of synthetic chemicals, not be produced on land to which any prohibited substances (including synthetic chemicals) have been applied during the three years immediately preceding the harvest of the agricultural product, and be produced and handled in compliance with an organic plan agreed to by the product's producer and handler as well as a certifying agent (U.S. Congress 2006g). This requirement includes the exclusion of any GMOs. As such, organic foods are de facto GMO-free products.

Labeling Genetically Engineered Food

Genetic engineering or modification is the method by which scientists introduce new traits or characteristics into an organism. For example, plants can be genetically engineered to produce characteristics that enhance the growth or nutritional profile of food crops. A majority of genetically engineered (GE) plants (such as corn, canola, soybeans, and rice) are typically used as ingredients in other food products. Federal law currently does not require manufacturers of GE food to include a label stating that the product is genetically modified. The FDA, however, has issued two draft guidance statements regarding the voluntary labeling of genetically modified food (USFDA 1997, 2001).

In its most recent guidance, the FDA stated that it is not adopting a formal policy requiring special labeling for genetically modified foods because it has no basis for concluding that bioengineered foods differ from other foods in any meaningful or uniform way, or that they present any different or greater safety concern than foods developed by traditional plant breeding. Labeling requirements that apply to foods in general also apply to foods produced using biotechnology. In determining whether or not a food is misbranded, the agency reviews label statements about the use of bioengineering to develop a food or its ingredients under Sections 403(a) and 201(n) of the FDCA.

State Laws

A number of states have passed laws related to process labeling. The most relevant of these laws relate to the labeling of rbST (also known as recombinant bovine growth hormone) in milk and, most recently, labeling of food containing ingredients that were genetically engineered. At least five states have enacted legislation or attempted to regulate claims on food products that are free of rbST, including Indiana, Kansas, Missouri, Ohio, and Pennsylvania. The common thread among all of the legislation, as reflected in the initiatives discussed later, is the typical conflict between proponents and opponents of labeling or the tension between principles of "consumer right to know" and "consumer need to know," as well as the pragmatic, business-oriented aspects of putting such labeling initiatives into practice.

In 2008, the Pennsylvania Department of Agriculture proposed a new rule that would have prohibited labeling indicating that a dairy product was rbST free or free of hormones. The department maintained that such claims were misleading and impossible to prove. After significant backlash, however, they rescinded the law in February 2009, stating that it would not prohibit the labeling of dairy products as rbST free as long as producers use the FDA disclaimer "no significant difference has been shown between milk derived from rbST-treated and non-rbST-treated cows" (USFDA 1994). Ohio attempted to enact a law aimed at banning the labeling of dairy products as "rbST free." The Sixth Circuit Court of Appeals, however, struck down the law in 2010 (*International Dairy Foods Ass'n v. Boggs* 2010).

At least 26 states have proposed labeling legislation for foods containing GMOs. Readers interested in this subject should refer to CAST Issue Paper 54, titled *The Potential Impacts of Mandatory Labeling for Genetically Engineered Food in the United States* (CAST 2014).

Whereas votes on initiatives related to GMO labeling in California, Washington, Colorado, and Oregon lost in elections, in May 2014 Vermont enacted "An Act Relating to the Labeling of Food Produced with Genetic Engineering," which requires manufacturers to label food products that are both offered for retail sale in Vermont and entirely or partially produced with genetic engineering (Vermont General Assembly 2014). The legislation requires segregation of GE and non-GE products and requires identity preservation throughout the supply chain. The law also provides a litigation alternative for mislabeling of such foods. Additionally, both Maine and Connecticut have proposed legislation regarding GMO labeling. These laws, however, take effect only after similar laws are enacted in other states. For instance, in Maine the law will take effect 30 days after certification to the Secretary of State that at least five other states, with a population of or a combined population of at least 20 million, have enacted similar legislation. Similarly, the law passed in Connecticut will take effect only after four other states with a population of at least 20 million have enacted similar legislation.

Consumer Behavior in Response to Process Labels

Once labels conform to the legal requirements, the assumption that truthful labels will always benefit (or at least will not hurt) consumers may seem like a reasonable one, but it can be unrealistic for several reasons. Because consumers are free to disregard information they do not find important or relevant, one could argue that providing truthful information via labeling can only facilitate consumer choices. Indeed, this is the argument at the heart of most "right to know" campaigns arguing for mandatory labeling of food attributes and production processes.

Whereas process labels can transform credence and experience attributes into searchable information, reading labels to acquire information requires cognitive effort. As argued by Jacoby, Chestnut, and Silberman (1977), "by placing information onto a package panel, we engage in printing, nothing more. The contention that this act of information provision is equivalent to communicating with the consumer represents an unverified assumption." Verbeke (2005) notes that "information is likely to be effective only when it addresses specific information needs, and can be processed and used by its target audience."

Within the food labeling and food choice context, quality is a multidimensional concept, wherein all the attributes valued by consumers are included (e.g., taste, product safety, healthiness and nutritional value, environmental friendliness, animal welfare). Yet for food products, several of these dimensions are not observable at the point of sale. So how can consumers make choices? Steenkamp's (1990) model of the quality perception process provides a useful conceptual framework. Absent the ability to assess quality directly, consumers form quality expectations based on visible product cues. These cues may include observable product characteristics that are physically part of the product (intrinsic cues) or elements of the packaging, including labels and producers' claims (extrinsic cues). The processing of cues into quality expectations is mediated by consumers' beliefs (Olson 1978), which are usually inferential and subjective in nature. For example, consumers may use observed meat color (an intrinsic cue) and the belief that "darker-colored meat is less fresh" to infer the safety of a steak. Attaching an expiration label to a product, therefore, is an attempt to promote and simplify this inferential process.

It should be noted that consumers face hundreds of decisions each day, and food choices are often made using simple heuristic rules. For example, Vega-Zamora and colleagues (2014) found that Spanish consumers used the label "organic" as a broad signal of higher quality, even though "they are not quite sure why." Thus, it should not be assumed that all consumers will acquire and process information in the same rational, objective way. As discussed in the following sections, in some cases labels may confound or misguide consumers and are unlikely to lead to improvements to the food and agricultural markets (Golan et al. 2001).

Importance of Control When Accepting Risks

Labeling of food can induce a negative consumer response to food products that have not been proved to cause any negative health consequences. Many experts, producers' associations, and policymakers regard public reaction to some types of perceived food risk as excessive and inconsistent with the scientific evidence. Indeed, the idea that lay people are "information deficient" and that there is a need to "educate the consumer" represents the starting point for many producer-driven informational campaigns.

A number of sociologists and psychologists (see Hansen et al. [2003] for a summary), however, point out that differences in how lay people and experts assess risks are not just the result of a knowledge deficit. Rather, consumers assess hazards on the grounds of several qualitative measures and not the unified, probabilistic scale adopted by scientists. Slovic (1987) suggests that consumers' response to risk is often driven by two major factors: dread risk, related to the potential for catastrophic consequences, and unknown risk, related to hazards of unknown nature or those delayed in their manifestation. Genetically modified foods are an example of a product that involves unknown risk because the potential problems with the food are uncertain and the problems may arise in the future. Fife-Schaw and Rowe (1996) found that "unnatural" (i.e., human-caused) hazards are perceived to be more severe than other perils that might be incurred because of "natural" causes. Similarly, people do not evaluate risks and benefits independently, but rather they pay close attention to who they perceive might benefit and who may suffer from the hazardous events (Alhakami and Slovic 1994). In light of these considerations, educating consumers about biotechnology may do little to reduce opposition to production processes if aversion results from the "unnaturalness" of the risks they entail and the fact that the benefits of the technology are expected to accrue to producers rather than consumers.

Another critical factor is how much control consumers believe they have in risky situations. Klein and Kunda (1994) point out that "people prefer controllable risks over less dangerous uncontrollable ones." A classic example of this preference is the widespread fear of airline travel, whereas study after study has demonstrated the higher risks associated with driving (or even walking). An explanation for this difference in perceived risk is the ability for one to have control when driving instead of just being a helpless passenger on an airplane. This sense of lack of control also has implications for food, and it is a key explanation regarding why consumers are interested in process labels and why many studies have been able to find changes in consumer behavior in response to such labels.

Can Process Labels Create Value for the Consumer and the Producer?

The majority of studies have found that consumers are willing to pay a significant premium for credence attributes that they either find desirable or wish to avoid. The beverage milk market, for example, features organic and rbST-free products in addition to conventional milk. Using scanner data, Bernard and Mathios (2005) found that consumers were willing to pay a premium of $0.73 per gallon for milk labeled as organic and $0.26 per gallon for rbST-free milk. Similarly, Kanter, Messer, and Kaiser (2009) found that consumers were willing to pay a premium of $0.29 per quart for organic milk compared with conventional milk. Dhar and Foltz (2005) examined the value consumers place on having organic and rbST-free milk as well as conventional milk in the marketplace. The authors found substantial benefits to consumers ($2.53 billion) in terms of the "competitive" and "variety" effects of having these two products in the market. These studies and others such as Liu et al. (2013) suggest that consumers (1) prefer having a market that offers the choice of conventional, organic, and rbST-free milk with labels that make these milks distinguishable, and (2) are willing to pay significant premiums for organic milk and somewhat smaller premiums for rbST-free milk compared with conventional milk.

Similar results have been found for other products and attributes. For instance, studies have shown that consumers are willing to pay a premium for production processes that are environmentally sound or "eco-friendly" compared with conventional practices. For example, Blend and van Ravenswaay (1999) surveyed 972 U.S. consumers and estimated that more than 40% of consumers were willing to pay a premium of $0.40 per pound or more for apples carrying an ecolabel compared with no label. Similarly, Loureiro, McCluskey, and Mittelhammer (2002) found consumers willing to pay an approximate 5% premium for apples that were produced using certified sustainable practices in the Pacific Northwest. Food labeled as "organic" also falls in this category because organic production practices rely on less chemical-intensive applications than nonorganic practices (McCluskey et al. 2003). Govindasamy and Italia (1999) found that a majority of U.S. households are willing to pay a premium for organic produce, and they developed a profile of demographic characteristics of households most likely to buy such products.

Search Costs and Information Overload

When consumers' interests are heterogeneous and the number of attributes and processes to potentially label is large, a key challenge is to establish how relevant the information is to the choices of most consumers. Lusk and Marette (2012) show that if consumers' attention to information is limited rather than infinite, additional information can distract consumers and complicate the search process, leading to a decrease in consumer welfare. Even though a particular piece of information may be of interest to some, the addition of a label will make searching more cumbersome for others. Just as unwanted e-mails generate clutter in inboxes, "massive over-information carries a cost for the consumer, in terms of time spent looking for the necessary information, as well as boredom or impatience" (Salaün and Flores 2001). McCluskey and Swinnen (2004) point out that if there is too much information on the product or if the information is difficult to interpret, consumers often ignore it and remain ignorant. This contention is supported by studies showing how this large amount of information decreases consumer attention, hampering the ability to detect and correctly identify labels such as those related to nutrition (Bialkova, Grunert, and van Trijp 2013).

One idea that is being proposed, including having been recently promoted by USDA Secretary of Agriculture Tom Vilsack, is to use smartphones as a way for consumers to get information as an alternative to on-product labeling (Keck 2015; Revkin 2014). Although this approach could certainly provide more information for the inquiring consumer, it is uncertain whether or not such technologies are suited for food markets, where consumers make a countless number of choices every day. Furthermore, whereas the number of smartphone owners has nearly doubled in the past four years to approximately 64% of adults in the United States (Smith 2015), the expense of smartphones makes this technology out of reach for many low-income households.

Neophobia, Technophobia, and the Strong Influence of 'Bad News'

The aversion to new foods, referred to as neophobia, is engrained in human instincts. Neophobia has a clear evolutionary explanation: it protects against the ingestion of potentially lethal toxins and pathogens. This is valid not only for humans, but for most species, especially the omnivores with broad and varied diets (Rozin 1976). In humans, the aversion to new foods is particularly marked for products of animal origin, perhaps because of their higher potential for being contaminated by pathogens (Pliner and Pelchat 1991). Given this aversion to new food, it is likely that process labels communicating the use of a specific technology—generally new and unknown to consumers—will induce an instinctive, negative reaction.

Costanigro and Lusk (2014) present evidence of this generic aversion to technology in the case of ethylene ripening. Ethylene, a naturally occurring hormone, is often controlled during storage to slow or accelerate the fruit ripening process (Sinha 2012), and many consumers use the same principle when they put a banana in a fruit bowl to promote ripening. Research has shown that a process label communicating that fruit was "ethylene ripened" induced a negative response on par with the aversion manifested toward GE products. Similarly, Lusk and Murray (2015) report that, when prompted in an online survey, 80% of consumers supported mandatory labeling of food containing deoxyribonucleic acid (i.e., the carrier of genetic information in living organisms).

Another reason consumers tend to respond negatively to technology labels is that when they do receive information, this information is most likely negatively framed. Swinnen, McCluskey, and Francken (2005) point out that consumers receive most of their information from mass media, which is much more likely to deliver "bad news" than "good news." Additionally, there is abundant evidence that people tend to weight losses (bad news) more heavily than gains (good news) (Kahneman, Knetsch, and Thaler 1991; Liaukonyte et al. 2013; Mizerski 1982).

Psychological and behavioral research has clearly shown that negative news dominates positive news, which is sometimes referred to as "negativity bias" (Kahneman, Knetsch, and Thaler 1991; Liaukonyte et al. 2013; Mizerski 1982). One explanation for this bias is that negative events are perceived to be increasingly more negative than positive events as the date of the event arrives (Rozin and Royzman 2001). For example, the negative feeling about taking an exam becomes even more negative as the date of the exam approaches, which differs from a positive feeling of, for example, going out to dinner, which may not change much as it approaches. An alternative, economic explanation regarding why negative news dominates positive news is the following. If utility is concave, the marginal loss in utility from not consuming the first bad news story is greater than the marginal gain in utility from consuming the first positive news story. In other words, if consuming more of a product provides an individual less additional satisfaction than the relatively large dissatisfaction that comes from a person consuming less of a product, then this would explain why negative news has a strong effect. Collectively, this creates a societal preference for negative news stories.

At the heart of this issue is a strong human tendency to avoid risk. The downside is that negative news can foster its own kind of ignorance, creating a heightened fear of risks that often differs from the scientific consensus. Genetically modified organisms are a good example. A recent study by the Pew Research Center, done in cooperation with the American Association for the Advancement of Science, revealed that 88% of scientists think genetically modified foods are safe. Yet only 37% of the public agrees (Pew Research Center 2015). No one has ever documented any harm from consuming GMO food, and any of the reported adverse effects were later retracted. Yet people continue to seek out articles that reinforce the idea that GMOs are dangerous.

Hayes, Fox, and Shogren (2002) show that when both scientific experts' opinions and more general negative unscientific information are given, the negative information dominates. Informational campaigns that often use messages that are positively framed—frequently invoked by industry groups to "educate" consumers—are often ineffective or have small impacts that deteriorate quickly. As mentioned previously, Frewer and colleagues (1997) found that information provided by experts, even from a trusted source, is short lived. When new information does become available—such as the National Academy of Sciences' declaration that GE food is not unsafe—this information may, in the short term, change very few people's assessment of the risks. A potential explanation of this response is that people are often reluctant to change their existing prior beliefs. When disconfirming evidence arises, people tend to avoid the information or misinterpret it in line with their existing beliefs (Steenkamp 1990), especially when the consequences are perceived as potentially catastrophic (Messer et al. 2011).

Direct and Indirect Stigma Effects of Labels

One potentially serious unintended consequence of process labeling is that it can unfairly stigmatize a product that the FDA has approved for consumption. Labeling some credence characteristics can send a signal to uninformed consumers that they should avoid or be worried about the overall safety of the product. For example, a consumer could be reluctant to consume products that are labeled to contain GE ingredients, not because of the objectively definable inherent risks of such ingredients, but simply because the label itself sends a warning signal about the product (Liaukonyte, Streletskaya, and Kaiser, in press).

One approach, often used when labeling is mandatory, is to communicate the use of a process technology with a "contains" or "made with" label. Examples of these types of labels include efforts to identify products that contain GE ingredients or apples produced with organic practices. An alternative approach, which is often preferred under voluntary labeling, is to certify the nonadoption of a certain production process via a "free of" label, such as ice cream made with milk free of rbST. The choice between these ways of framing may seem inconsequential, but it can often be quite important. Using "contains" labels tends to induce a negative consumer reaction (in terms of decreasing willingness to pay [WTP]) that is much larger than the corresponding increase in WTP observed for "free of" labels (Costanigro and Lusk 2014; Hu, Adamowicz, and Veeman 2006; Liaukonyte et al. 2013). Thus, the result of mandated "contains" process labels is the likely dismissal of FDA-approved technologies, and ultimately a reduction in available choices.

Economists have examined stigma by determining whether or not a label has a significant negative effect on consumers' WTP. Stigma may occur either directly with labels such as "contains" or indirectly with labels such as "free of." Several studies have documented large, labeling-induced negative impacts on WTP (e.g., Costanigro and Lusk 2014; Hayes, Fox, and Shogren 2002; Kanter, Messer, and Kaiser 2009; Liaukonyte, Streletskaya, and Kaiser, in press; Liaukonyte et al. 2013; Lusk et al. 2005; Marette 2014). For example, in a recent comprehensive study of seven ingredients or production practices (GMOs, irradiation, growth hormones, antibiotics, trans fat, high-fructose corn syrup, and artificial dyes), Liaukonyte and colleagues (2013) found that subjects' WTP was 67% lower, on average, for products carrying a "contains" label for such items compared with a control group that did not see the label. Lusk and colleagues (2005) also found negative, but somewhat lower, impacts in their meta-analysis based on 25 studies encompassing 57 food items containing GMOs in 12 different countries. These authors found that, on average, consumers' WTP for foods containing GMOs was 23% to 28% lower than their non-GMO counterparts. Thus, the process labels become somewhat similar to the health warnings common to cigarettes or alcohol and support consumers' general concerns about the uncertain source of some medical and environmental problems.

This large decrease in WTP has been described as an example of stigma because some consumers do not make calculated trade-offs between benefits and risks, but instead they simply "shun" a product regardless of price (Hoffman, Fooks, and Messer 2014; Messer et al. 2006; Wu et al. 2015). In other words, process labeling to promote the benefits of one technique can stigmatize the conventional product because the label portrays the conventional product in an implicitly negative way.

An illustration of this phenomenon was the introduction of rbST-free milk, which carried a label that the product was free of rbST, a synthetically produced version of the naturally occurring bovine somatotropin. Kanter, Messer, and Kaiser (2009) conducted research designed to measure whether or not the introduction of rbST-free milk stigmatizes consumers against conventional milk. The authors found that the "rbST-free" label alone had a substantial stigma effect on conventionally produced milk, lowering participants' WTP for conventional milk by 33% compared with subjects who did not see the rbST-free label prior to considering buying the conventional milk. Whereas 33% is the result that comes from the average of the consumer responses, a more detailed review of the data suggests that a significant portion of this decrease comes from individual consumers who refused to purchase the product regardless of the price. Many other examples exist in which conventional commodities can be indirectly stigmatized by the introduction of new, but similar, products that carry process labels implicitly portraying the conventional technology in a negative light—e.g., shade-grown coffee, dolphin-safe tuna, and free-range chicken.

Misinterpreting the Meaning of Labels

Although studies reporting positive or negative WTP for labeled attributes are often cited as evidence of consumers' preference or aversion to a certain product, another line of the academic literature has demonstrated that consumers value process labels because they signal specific quality improvements (Steenkamp 1990). For example, consumers may have the belief that organic production is directly related to positive attributes such as increased product safety, healthiness, and environmental good, even if these benefits have not been scientifically demonstrated. Therefore, consumers' response to and WTP for a label reflects both their preferences and their beliefs. Whereas preferences are generally internal to an individual and more stable (Lusk, Schroeder, and Tonsor 2014), beliefs are more malleable and can be swayed by marketing and advertising or they may simply be incorrect. For example, some consumers have a significant WTP for decreasing the distance traveled by food (Grebitus, Lusk, and Nayga 2013). The observation that some consumers value "low food miles," however, tells us little about the societal effects of a mile-labeling system. If consumers believe that low-food-miles tomatoes decrease environmental impact, but such tomatoes are grown in energy-intensive greenhouses, consumers may actually be paying a premium to obtain the opposite of what they want (Costanigro, Deselnicu, and Kroll 2015).[4]

The previous example shows an important challenge of process labels, namely that consumers need to engage in inferential processing using their subjective beliefs to interpret the information the label contains. From a public policy standpoint, this inferential

[4] According to recent evidence, food miles are a rather poor indicator of environmental quality (Coley, Howard, and Winter 2011; Smith et al. 2005). Although transportation does generate pollutants, the biggest environmental impact occurs during the food production process, not the transportation phase (83% vs. 17%, according to Weber and Matthews [2008]).

process is undesirable (Steenkamp 1990). Direct information about the relevant quality dimensions, on the other hand, does not necessitate consumer inference. Consider an analogy, once again from auto sales: When purchasing a car, drivers are generally concerned about fuel efficiency. Providing information about the engine size, catalytic converters, and car weight may be helpful, but consumers will still need to form inferentially their expectations and estimates about how these factors affect fuel efficiency. In contrast, the miles-per-gallon sticker—or, even better, a gallon-per-miles sticker (Larrick and Soll 2008)—that is displayed on the windshield helps solve the problem because this label provides the necessary information most directly.

In the context of food, research has shown that certain cues or labels may be misinterpreted by consumers, and sometimes they even induce a cognitive bias called the "halo effect." For instance, Schuldt, Muller, and Schwarz (2012) found that the label of "fair trade" made some consumers believe that the food had lower calories than it really had. For organics, Lee and colleagues (2013) found a similar "health halo" effect biasing downward calorie perception and even altering (positively) taste and sensory evaluations. So process labels, such as "organic" and "fair trade," will be inevitably interpreted to mean some things (good and bad) that the label is not designed to communicate. In contrast, the nutrition labels currently on food provide information, such as the calorie count, limiting the need for inferential interpretation because they directly communicate the nutritional outcomes determined by the chosen ingredients and production processes.

Food Labeling and Technological Progress

In the short term, mandatory labels can impose significant costs to producers or governmental agencies and these costs are often partially transferred to consumers in the form of higher prices (Golan et al. 2001). If labeling costs exceed consumers' WTP for the information, the label as a public policy fails on a benefit-cost basis. Additionally, if mandating process labels results in increased food prices, the biggest impact will fall on the poor, who spend a considerably larger share of their income on food than do more wealthy members of society. In fact, despite the observed decline in average food prices, the cost of the cheaper food generally consumed by lower-income people has not changed significantly in the past 30 years (Thompson 2013). Another short-term impact of food labeling is the need to segregate the assembly, processing, and distribution for process-oriented technologies, which can be very expensive.

Several cases demonstrate how, even when labeling costs are small, distributing more information may fail to deliver the expected gains in consumer choice or have unintended negative consequences in the long term. In the case of mandatory labels, Golan, Kuchler, and Krissoff (2007) note that when firms are forced to disclose negatively perceived characteristics, they often choose to reformulate their product to avoid the labeling requirement. For example, the mandate to label trans fats in food after scientific evidence demonstrated their negative impact on human health resulted in the virtual elimination of trans fats from the food supply chain (Brandt, Moss, and Ferguson 2009; Rahlovky, Martinez, and Kuchler 2012). In this case, the mandatory labels led to a positive result for human health, given the scientific evidence.

For controversial technologies, however, the imposition of mandatory labels may induce firms to completely dismiss a technology recognized as safe but negatively perceived by consumers. One such example is the case of ionizing radiation in the United States, a technology that has been proved effective in decreasing foodborne pathogen contamination, extending the shelf life of some fruits and vegetables, and controlling infestation by insect pests (USGAO 2000). Many studies have investigated the effect of irradiation on food, and the general scientific consensus is that there are no significant negative health effects associated with food irradiation protocols (Diehl 1995). The World Health Organization also agrees that irradiated food presents no toxicological risk, and U.S. regulatory agencies (the FDA and USDA) approved the use of ionizing radiation in a large number of foods: spices and dried vegetable seasoning (1983), pork (1985), fresh fruit and vegetables (1986), poultry meat (1990), ground beef (1997), shell egg (2000), sprouting seed (2000), and mollusks (2005) (Kava 2007).

While the technology is recognized as safe, radiation is a process that may change some intrinsic quality of a food (e.g., some vitamins are partially degraded), and therefore FDA mandated the labeling of irradiated food with the distinctive Radura logo. Unsurprisingly, irradiated food faced resistance from consumers and activist movements, who are alarmed by the idea of eating food exposed to radiation. Whereas in experimental settings scientific information about the incidence and severity of foodborne diseases and the benefits of irradiation has been found effective in persuading consumers, Fox, Hayes, and Shogren (2002) demonstrated that negative information from activist groups, even if unscientific, carries more weight in swaying consumer choices than factual, science-based information. Fearing a negative reaction from consumers, the food industry has generally shied away from the technology and substituted approaches not requiring a label, which include "natural" approaches (e.g., heat processing or freezing) but also chemical disinfection (e.g., fumigation of imported food with methyl bromide for quarantine purposes). According to a report from the General Accounting Office (USGAO 2000), the most significant use of food irradiation in the United States is made by health care providers concerned about protecting immunosuppressed patients from foodborne illnesses.

Another example is that of GE products. Alston and Sumner (2012) argue that mandating GE labels would have the effect of being an implicit ban on food containing ingredients from genetically modified plants or products. The authors cite public opinions showing that, although the majority of the California public voted against mandatory labeling, 85% would refuse to buy products if they knew those products were produced with GE ingredients. Hence, mandatory labels could act as a pseudo ban on products produced with genetic engineering and other production practices not viewed positively by the public. Paradoxically, labels intended to give consumers more choice can result in market outcomes in which the number of available choices diminishes.

Similar outcomes have also occurred when voluntary labels have been approved to certify the absence of a controversial technology, as happened with the use of growth hormones in dairy production. As described by Runge and Jackson (2000), after rbST was approved for use on dairy farms by the FDA, some food retailers began carrying fluid milk products with the label "rbST free," which eventually resulted in customers contacting large food retailers such as Walmart, Krogers, and Publix with concerns that their milk might have growth hormones in it and be unsafe to drink. These supermarkets responded by notifying their fluid milk suppliers that they would no longer buy any milk produced from cows that were given rbST. Milk processors had to adopt segregation processes to ensure that rbST and rbST-free milk were not comingled at any point in the production process—from the farm, through the trucking process, and ultimately through the packing process.

This segmentation of the milk supply adds significantly to the retail price of fluid milk products. Soon, other large food companies followed suit in banning rbST-produced milk, including Starbucks and Dean Foods, which is the largest distributor of fluid milk products in the United States. The end result is that today virtually all fluid milk products sold in the United States do not contain milk produced from cows given rbST. Consequently, even though the FDA approved rbST for commercial practice after extensive safety trials, the use of voluntary labels led to an implicit ban on it, at least for fluid milk products.

If mandatory labeling of food processes becomes more frequent in the United States, one possible major long-term consequence will likely be a curtailment of the historical steady rate of technological progress. In addition to the effects on controversial technologies, some authors (Teisl and Roe 1998) have argued that process labeling may cause excess inertia and a lagged response to changes in available technology and consumer preferences. For example, modifying the protocol for organic production is a lengthy process fraught by institutional bureaucracies and coordination difficulties. Some researchers already believe that farm productivity growth is in decline in the United States (Alston, Andersen, and Pardey 2015). Placing additional constraints on productivity because of fears of negative consumer response to new technology could make things worse. This could result in an abrupt decline in research and development by both the private and public sectors in promising new technologies, particularly those involving biotechnologies.

Although U.S. agricultural research and development may shift from biotechnology to other types of agricultural technologies, Alston and Sumner (2012) argue that this shift could seriously thwart the competitiveness of U.S. agriculture in the world market, especially considering that China and Brazil have recently increased their own research and development in biotechnologies. Given concerns about meeting future food demand for a growing world population and uncertainty regarding how climate change will impact agricultural yields, it will be crucial for the United States to continue pursuing technological progress and increased yield productivity.

Conclusion

This paper presents a systematic review of the current use of food process labels and their effects on food and the agricultural sector. Five primary points can be made about the consumers:

1. Consumers want to have a sense of control over the foods their families eat.
2. Food markets are characterized by asymmetric information. Producers know more about the quality of the products than consumers. Many important quality traits are unknown until after consumption, or they are never revealed.
3. Consumers are not well informed about the various technologies used in the agricultural and food sector of the United States; however, they have greatly benefited from the tremendous technological progress that has occurred over the past century.
4. Consumers use process labels as cues to infer quality traits that are important to them, such as taste, food safety, and the environmental and societal impacts.
5. There is strong evidence that consumers consider process labels, frequently adjust their behavior in response to them, and, when these labels imply a negative aspect of a food, can shun that product.

Given these consumer preferences and behaviors, marketers should also be expected to use labels as a way of distinguishing and creating a unique brand for their products. To the extent that process labels help consumers substantiate better-informed and realistic expectations about product quality, they are a good thing. Process labels can create value for producers and consumers by increasing the number of choices (product differentiation) and creating new market segments for producers. Labels can also help to remove food products, such as trans fat, that are scientifically shown to be harmful to human health. This win-win situation, however, does not always materialize because there are a number of challenges that arise with the consumer response to these labels:

- A fundamental problem with process labels is that they are subject to consumers' interpretation; that is, the effect of the labeled process on the relevant quality traits needs to be inferred by consumers and often is not based on scientific evidence.
- This inference is difficult, especially for credence aspects, because consumers never really observe the quality outcomes the label is supposed to predict (e.g., the effect of organic production on environmental impact). Consumers can also be exposed to marketing messages that

can be misleading, and the media tends to focus on bad news.

- The inferential nature of process labels and the proliferation of their use in the food market can cause increased search costs for consumers and rejection of new technologies stemming from consumers' aversion to eating unknown products.
- Process labels can be used by marketers to stigmatize rival conventionally produced products, even when there is no scientific evidence that food produced in this manner causes harm.

These issues may cause a reduction in productivity growth because the uncertainty regarding the consumer response to a new technology may discourage investment in research and development of new science and technology in the agricultural sector.

In light of these observations, the authors suggest the following policy recommendations related to process labeling:

- Mandatory labeling should only occur in situations in which the product has been scientifically demonstrated to harm human health.
- Governments should avoid imposing bans on process labels because this approach goes against the general desire of consumers to know about and have control over the food they are eating. This approach can backfire because it can undermine consumer trust in the agricultural sector.
- Voluntary process labeling can help consumers make informed decisions. Some conditions need to be required, however, to avoid causing false implications related to competing products. (1) The labeling claims must be true and scientifically verifiable. This condition should hold for all claims related to labor practices, environmental impact, or effects on human health. (2) The process labels claiming a product "contains" or is "free of" a certain production-related process should also include labels on the package stating the current scientific consensus regarding the importance of this attribute. This would help prevent the problems of implicit deceit.

Additionally, there are a few recommendations for the firms in the agricultural sector. A first recommendation is that if mandatory process labels are required, then food retailers may want to use additional (secondary) information with the labels to mitigate the potential negative effects of labels on the demand for their products. For instance, Liaukonyte and colleagues (2013) found that although the process label "contains" a certain process had a large negative effect on consumers' WTP, when the same label was combined with positive secondary information about the process, consumers' WTP was no different than that of consumers who did not see the label. Secondary information can also be important when labeling that a product is "free of" an ingredient or production practice. The implication of this research is that if mandatory labeling becomes law, food retailers should be able to mitigate some of the negative impacts of labels by promoting positive information about the ingredient or production process that is being labeled.

A second recommendation for industry is to keep in mind how the consumers think and try to pair supply-side technological development with clear consumer advantages. For instance, the process label of "vine-ripened" tomatoes arose in response to perceived deteriorating taste quality of tomatoes due to production and supply chain-oriented technological development (Bruhn et al. 1991). This situation created a market opportunity because the tastier tomatoes could market their production processes. In a way, the whole organic and alternative food movement can be interpreted as a signal to the food industry that cheap and plentiful food should not come at the cost of wholesomeness, the environment, and eating quality. Science-based technological progress in agriculture, however, does not necessarily need to focus on productivity gains, and it can be redirected toward other objectives. Nutraceutical and functional foods represent a step in this direction, but there is a vast potential to use science and technology to produce healthy, tasty, and safe products in an environmentally conscious way.

Finally, producers and policymakers should begin to think more about what a next-generation process label should look like. Ultimately, process labels are the second-best solution to the inherent asymmetry in the food market. The proliferation of the number of voluntary process labels in the market is a testament to the fact that they can be relatively cheap to adopt for some producers and can be effective at attracting consumers. The opportunity to use smartphone technology and voluntary bar or quick response codes placed on the products to provide consumers with more information is an intriguing idea worthy of exploration in the future. The challenge with both these new codes and traditional food labels is whether or not to develop information that more directly assesses the quality dimensions consumers are trying to gauge. Moving away from dichotomous (yes/no) labels could be a good approach. Instead of coffee being either "bird friendly" or not, perhaps it could be given a 1–10 score or a letter grade on its environmental impact as determined by a scientific assessment. An example in the context of building is Leadership in Energy and Environmental Design certification, which has four levels: certified, silver, gold, and platinum. Bringing this into the context of agricultural products would be a positive step forward for both consumers and producers.

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Citation: Council for Agricultural Science and Technology (CAST). 2015. *Process Labeling of Food: Consumer Behavior, the Agricultural Sector, and Policy Recommendations*. Issue Paper 56. CAST, Ames, Iowa.

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