Unlocking food security: the power of labelling in consumer trust and safety

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Abstract: Food safety and food security are critical to public health, economic stability, and national security. This study explores the role of food labelling in strengthening food safety by enhancing consumer trust. To investigate this relationship, we conducted a literature review, selecting studies based on predefined inclusion and exclusion criteria. The review focused on peer-reviewed studies published in English between 2014 and 2024 that investigated the association between food labelling and food safety and security. Improved food labelling can ensure that consumers have access to reliable and accurate product information, thereby mitigating food insecurity. In addition, the adoption of digital food labelling systems and certification mechanisms can improve food safety outcomes and enhance consumer trust.

1 Introduction

Food security has evolved from a narrow concept of food supply and availability to a multidimensional concept that encompasses economic, social and cultural aspects[1]. Ensuring food security requires not only adequate supply but also safe, nutritious and accessible food. Food safety is a fundamental component of food security, ensuring that food is free from contamination and fit for consumption, providing nutritional value[2]. Without food safety, the broader goal of food security cannot be fully achieved, as hunger causes anxiety and fear, or contaminated, unsafe food undermines health and well-being[3-8].

Food labels are a direct channel of communication between manufacturers, retailers, regulators, third-party certification bodies and consumers[9]. This study examines the interaction between food safety, food safety and food labelling, analysing mandatory information (such as nutritional content, production date and expiration date) and voluntary labelling (such as organic certification and GMO-free claims). In addition, we assess how emerging technologies, including blockchain and AI-based traceability systems, can improve the transparency and credibility of food labels. Given the increasing complexity of food systems and the growing need for transparency, this study focuses on the role of food labels in strengthening food safety, particularly by increasing consumer trust. Furthermore, food insecurity can

exacerbate conflict and undermine regional stability. Integrating food systems into national security frameworks can enhance the resilience of food systems and reduce vulnerabilities that can be exploited in times of crisis by focusing on the intersection of food safety, security and technology.

2 Methodology

For studies on food labelling with safety and security, we developed research questions and inclusion and exclusion criteria. The inclusion criteria used in this systematic review were (i) focusing on the relationship between food labelling and food safety and security (ii) academic peer-reviewed journals and research articles, (iii) publications written in English, and (iv) papers published within the research timeline (2014-2024). Exclusion criteria were those that (i) were not relevant to the topic of interest.

3 Results

3.1 The relationship of food security and food safety

Food security has evolved constantly since its initial definition in the 1970s by World Food Conference(1974), defined food security as food supply - assuring the availability and price stability of basic foodstuffs at the international and national level [10]. According to World food summit in 1996, they state that food security is “Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life [11]”. FAO divides food security into four parts: Food availability(supply and resource); food Access(affordability or social safety; utilization(sustain health and well-being) and stability(development and sustainability) [1],which improved food security in terms of availability and access, market development, natural resource management and access to basic services. The focus of food security has shifted from food supply, food availability to a broader definition. This shift reflects an increasing understanding that food security involves multiple dimensions that includes economic (economic access to food), social, and cultural aspects associated with well-being (food preferences, quality, safety, and nutrition) [2]. Food insecurity impacts well-being especially in less developed country [4, 12]. Food insecurity well-being includes three factors: (i) sensory experiences(hunger) [3, 4]; (ii) affective experiences(such as anxiety and

fear, mental health is found to be strongly associated with food insecurity [5-8]); and (iii) evaluative experiences(relative deprivation) [13].

Food safety is a foundational aspect of food security. Food safety involves foodborne illness and includes the handling, preparation and storage of food [14]. Food safety is an essential component of food security, particularly in the context of food utilization [1]. Food safety refers to the entire process from food production to consumption, ensuring that food is safe when eaten and does not cause harm to consumers' health [15]. It includes: pollution prevention and control: preventing food from being contaminated by biological (such as bacteria, viruses), chemical (such as pesticides, heavy metals) and physical (such as foreign matter) [16-18]; handling and storage: ensuring that food remains hygienic and safe during production, processing, transportation and storage [19, 20]; and regulations and standards: complying with relevant food safety regulations to ensure food traceability and controllability [15, 21, 22].

Figure 1
The relationship between food security and food safety

Among them, the standards and systems commonly used in food safety assessment are: HACCP (Hazard Analysis and Critical Control Points; ISO 22000 (Food Safety Management System); GFSI (Global Food Safety Initiative; IFS (International Featured Standards; FSSC 22000 (Food Safety System Certification 22000, Food Safety System Certification); Codex Alimentarius (Food Code); FSMA (Food Safety Modernization Act) of the United States; Regulations of the European Food Safety Authority (EFSA); China's national food safety standards (GB standards), etc., as shown in Table 1. These standards and systems mainly include international, regional and national food safety standards to ensure that all links in the production, processing, transportation and sales of food meet the requirements.

As mentioned above, food security focuses on whether food can be effectively obtained and continuously supplied, including four key elements: availability, accessibility, utilization and stability. The utilization part is closely related to food safety, ensuring that the food obtained is safe, nutritious and suitable for consumption. Without food safety, the other dimensions of food security—particularly access and utilization—cannot be fully realized, as unsafe food undermines the very goal of providing nutritious and reliable sustenance. Thus, food safety acts as a foundation for achieving broader food security.

In the situation of resource constraints, food security prioritizes concerns about persistent food shortages and hunger when hunger is more urgent to be addressed than food safety [23]. However, generally food security always prioritizes food safety over healthy nutrition [24]. To establish healthy and sustainable food production and food systems, food safety is also very important, and food safety and food security must be combined to meet the food security challenges facing humanity.

Standard	Description	Application	Aera
HACCP	Hazard Analysis and Critical Control Points	Food manufacturing, processing, catering, etc.	Global
ISO 22000	ISO 22000 helps Food Safety Management System	Food supply chain	Global
GFSI	Global Food Safety Initiative	Retail, food manufacturing, supply chain, etc.	Global
IFS	International Featured Standards	Food Manufacturing (retailers and suppliers)	Europe
FSSC 22000	Food Safety System Certification 22000 based on ISO 22000, recognized by GFSI.	Food production, processing and manufacturing enterprises	Global
Codex Alimentarius (Food Code);	It developed by the United Nations and the World Health Organization	All types of food	Global
Regulations of the European Food Safety Authority	It covers standards for food additives, residues and other aspects.	All types of food	Europe
China's national food safety standards (GB standards)	It issued by the Chinese government stipulate requirements for food additives, pesticide residues, etc.	All types of food	China

Table 2
The standards and systems commonly used in food safety assessment

3.2 Food labelling: a way to enhance food security

3.2.1 Food labelling guidelines

Food labels refer to information on prepackaged food [25]. "Prepackaged" means packed or prepared in advance in a container and ready to be provided to consumers or for catering purposes. The internationally recognized definition of food labelling is any label, brand, mark, picture or other descriptive material, etc. In modern society, food systems are often made up of long supply chains, which results in a large degree of separation between consumers and growers, reducing consumers' understanding and involvement in food production [26]. Food labels are the main way for consumers to obtain food-related information, also seen as a policy tool to help transition to healthier, more sustainable food systems. At the same time, food producers are very interested in using product labels to inform consumers about the quality of their products and brands at the point of purchase, and to connect with consumers [25]. Food labels refer to information on pre-packaged food, "Pre-packaged" means packaged or made up in advance in a container, ready for offer to the consumer, or for catering purposes. The internationally recognized definition of food label is any tag, brand, mark, pictorial or other descriptive matter, written, printed, stencilled, marked, embossed or impressed on, or attached to, a container of food [27]. According to the General standard for the labelling of prepackaged foods by Codex Alimentarius Commission, the following information is mandatory labelling content: the name of food; list of ingredients; net content and drained weight; name and address of the manufacturer, exporter, importer, packer, distributor or vendor; country of origin; lot identification; date marking and storage instructions; instructions for use; The Codex Alimentarius Commission also provides for the following eight foods and ingredients known to cause allergies should always be declared on the label as table 2 showed. (wheat, crustacean shellfish, egg, fish, peanuts, and soy, milk, tree nuts and sulfurizing agents when Sulphite in concentrations of 10 mg/kg or more) need to be labelled [27-29]. If the food has been treated with ionizing radiation, a written statement must be attached [27]. In some cases, quantitative labelling of ingredients is also required. According to Codex general standard for the labelling of pre-packaged foods must not be described or presented on any label in a manner that is false, misleading or deceptive or as this could create an erroneous impression in any respect as to their characteristics [27]. Since consumer trust is an important driver of consumer food choices [30, 31]. It follows that, food labels play a vital role in build customer trust. Therefore, ensuring accurate and transparent food labels helps consumers make healthier and safer food choices [32].

Currently, although the pre-packaged food labelling guidelines around the world are based on the Food Codex Alimentarius of the Food and Agriculture Organization of the United Nations(FAO) and World Health Organization(WHO) , there are great differences in specific regulatory requirements among countries [25].

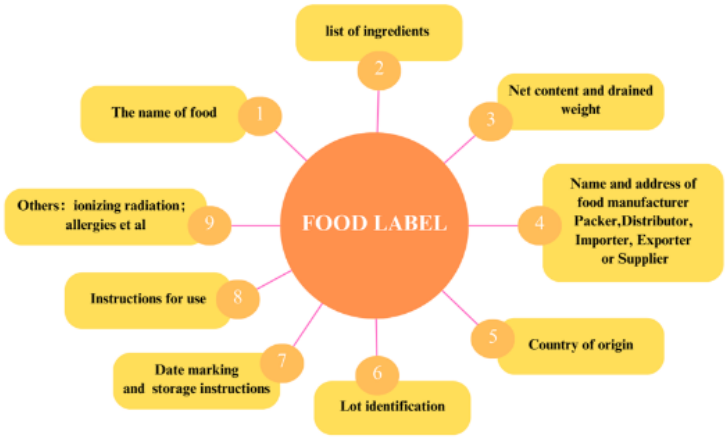

Figure 2
Content of food label

	Type of foods and ingredients known to cause hypersensitivity
1	Cereals containing gluten; i.e., wheat, rye, barley, oats, spelt or their hybridized strains and products of these
2	Crustacea and products of these;
3	Eggs and egg products
4	Fish and fish products
5	Peanuts, soybeans and products of these;
6	Milk and milk products (lactose included)
7	Tree nuts and nut products
8	Sulphite in concentrations of 10 mg/kg or more

Table 3
Mandatory labelling - foods and ingredients known to cause allergies

3.3 Food labelling with food security and consumer trust

Food labels are a direct communication channel between manufacturers, retailers, regulators and third-party certification bodies and consumers[9]. Research on the credibility of food labels plays a key role in food security research[33]. When consumers doubt label information, it may affect their trust in product quality, which in turn has a negative impact on their purchasing decisions. In addition, inaccurate or ambiguous label information (such as unclear expiration dates and

opaque ingredients) may cause consumers to refuse to buy and even cause food waste[34]. With the development of emerging technologies (such as blockchain, food traceability systems, artificial intelligence), the transparency of the food supply chain has been significantly improved[35, 36]. These technologies help enhance the authenticity of food labels and increase consumer trust in labels[37, 38].

Given the increasing complexity of food systems and the growing need for transparency, this study focuses on the role of food labelling in strengthening food safety, particularly by increasing consumer trust.

By analyzing mandatory information on labels (such as nutritional content, production date, shelf life, etc.) and voluntary information (such as organic certification, GMO-free, etc.), we can explore the differences in consumers' perception and trust in labels. In particular, how emerging technologies such as blockchain and AI-based traceability systems can enhance the transparency of the food supply chain, improve consumers' trust in food labels, and provide a reference for optimizing the safety of food label design.

4 Discussion

Food labels are a bridge between food safety policies and consumer behavior. Accurate and transparent labels are essential to foster consumer trust and reduce food-related health risks. In addition, emerging technologies have a positive impact on food labelling transparency. Blockchain technology enables safe, tamper-proof traceability in the food supply chain, providing consumers with verifiable information about product origins and safety standards. Similarly, AI-driven certification systems can improve labelling accuracy and prevent fraudulent misrepresentations. By integrating these technologies into food labelling systems, regulators and industry stakeholders can improve food safety and minimize the risks associated with mislabeled or contaminated products.

Another aspect is the psychological and behavioral response of consumers to food labels. Clear and easy-to-understand labels have a positive impact on purchasing decisions, reduce uncertainty and improve product safety. Distrust in food labels, especially in regions with a history of food safety scandals, can lead to people being reluctant to consume products and even cause food waste. Therefore, enhanced public education on food labelling and improved regulatory enforcement can enhance consumer confidence.

In addition, this study highlights the broader safety impact of food labelling. In crisis situations such as conflict or natural disasters, ensuring the authenticity and traceability of food sources is critical. A robust food labelling framework can serve as a national security tool to prevent food fraud, mitigate economic disruptions and promote stability in the food supply chain.

Conclusion

This study highlights the critical role of food labelling in improving food safety and consumer trust. Blockchain and AI-driven labelling systems offer promising solutions to improve traceability, prevent food fraud, and ensure compliance with safety standards. Future research should explore the long-term impact of digital food labelling on consumer behavior, especially in different cultural contexts. Policymakers should also consider harmonizing food labelling regulations to facilitate international trade and enhance global food security, so that food labelling can become an important tool to achieve a safer and more transparent food system.

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