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ROTH B. Blockchain-enabled consumer engagement: an emerging pandora to safer food and enhanced consumer trust? (Chinese and English versions)[J]. Science and Technology of Cereals, Oils and Foods, 2024, 32(4): 24-32.

消费者参与区块链技术赋能：食品安全性与消费者信任提升的新兴潘多拉效应？（中英文）

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摘　要：目前，食品安全治理亟需采纳涵盖消费者参与的共治模式，以应对日益复杂的食品安全挑战。企业已经部署了基于区块链技术的去中心化食品追踪系统，这一创新举措旨在通过激发消费者主动参与，显著增强他们对食品安全治理体系的信任度。本文综合社会科学、经济学以及食品安全治理领域的跨学科理论，深入探讨了影响消费者参与度和信任度的因素。为此，着重分析了区块链技术实施在加深消费者信任方面的潜力和影响。还提出一个包含理论分析与实证研究的综合研究议程，以期为全球食品供应链中区块链技术的应用及其对消费者信任的影响提供更深理解。

关键词：食品安全；消费者参与度；区块链；食品可追溯性；信任
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Blockchain-enabled Consumer Engagement: An Emerging Pandora to Safer Food and Enhanced Consumer Trust? (Chinese and English versions)

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Abstract: Currently, there is a growing call for a co-governance approach that includes consumers in food safety governance. To address this, corporations have implemented decentralised digital food traceability systems based on blockchain. Many argue that this technology will lead to enhanced consumer trust in food safety governance through greater consumer engagement. In this regard, this paper examines factors that

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influence consumer engagement and trust in food safety governance, mobilising interdisciplinary literature from the social sciences, economics and food safety governance. By doing so, it explores the implications of the implementation of blockchain as a means of enhancing consumer trust. The paper raises critical questions on a global scale and offers a social science and wider empirical perspective that has received less attention. To further investigate the effects of blockchain on consumer trust in the food supply chain, it proposes a research agenda that includes theoretical and empirical research.

Key words: food safety; consumer engagement; blockchain; food traceability; trust

根据欧洲食品安全局（EFSA）的报告[1]，全球频繁爆发的食品欺诈案例涉及肉类、酒精饮料、牛奶及其他乳制品以及蔬菜等多个产品类别。食品欺诈可以在不同层面上发生，因此，区分食品欺诈和食品安全事件非常重要，是否具有危害公众健康和环境的意图是区分它们的一个关键因素[2]。不是所有的食品欺诈类事件都直接影响公众健康，有些可以归类为蓄意欺骗消费者，比如生产者为了经济利益[3]。即使对公众健康没有影响，这种食品欺诈也可能导致公司的声誉受损，并使消费者丧失对公司和监管当局的信任。Spink 和 Moyer[3]在 2011 年提出的食品欺诈定义："是为获得经济利益故意替代、添加或篡改食品、食品配料或食品包装，或者错误、误导性地陈述产品"。尽管监管机构和食品公司实施了许多防止食品安全事件爆发的措施，如 DNA 测试和危害分析关键控制点（HACCP），但食品欺诈仍然是一个重大挑战[4]。此外，Giampiteri 等[5]指出，在全球复杂的食品供应链中建立消费者信任面临着重大挑战，同时强调了可持续性、食品安全和保障的重要性以及全面关注这些问题的必要性。然而，要实现这一目标，需要对现有的食品安全治理模式进行根本性的调整。许多学者呼吁从整体上看待食品安全治理，让多方参与者共同努力解决相关问题[6-8]。

在此背景下，许多企业提出了基于区块链的解决方案，旨在通过共管共治和消费者的直接参与，提高对食品供应链的信任和透明度。通过其去中心化的特性，区块链技术已在世界范围内广泛用于支持物流和优化供应链。它一般与加密货币支付系统相关联，并起源于该系统[9]。作为一个去中心化的系统，区块链利用分散式账本技术创建了一个安全且加密的数据库[10]。通过将数据组织成相互关联的块[11]，不仅确保了信息的完整性，还有效防止了信息被篡改。在区块链的体系中，任何试图操纵或更改数据的行为都需要对整个系统进行修改。对相关各方参与者，这就会保证数据防伪性。作为一种多方参与的新兴食品追溯系统，区块链的核心植入共治方案，采用 2008 年由 Nakamoto 引入的点对点交互方式和共识算法来验证信息[9]。其目的旨在建立信任，并确保整个供应链上信息的有效性和可靠性。最终的目标是致力于实现更安全的食品供应链，并极大减少个体参与者的欺诈或投机行为[12-13]。

区块链技术在食品供应链的应用，为消费者提供了一种从源头到餐桌的全链路可追溯信息，使他们能获得食品质量、安全及产品性方面的详细信息并参与其中。消费者及供应链中的各方参与者，仅需扫描食品包装上的二维码，即可获取经过区块链验证的详尽信息。因为这种增强透明度和参与度的理念，越来越多的国内和国际食品公司正在采用区块链作为新的食品可追溯系统。在中国的一家跨国超市先行实践，将区块链技术与食品安全治理及可追溯性结合，开辟了行业先河。随后，欧洲部分超市也在近几年开始对特定食品采用区块链追踪。所以，食品供应链中应用区块链，是食品追踪溯源的一个新兴趋势，也突显了全球范围内深入了解其效果和影响的重要性。

学术界已广泛探讨了区块链技术在食品供应链中的应用，涵盖了技术创新[14-18]和管理策略[19-21]等多个维度。然而，从社会科学视角深入理解区块链如何影响消费者信任、以及其对食品领域参与者角色的改变，这方面的研究相对缺乏[22-25]。da Silva 和 Moro[26]等科学家们呼吁研究人员来进一步弥补这一空白。从社会科学和更广泛的经验

角度来看，区块链提出了一系列针对信任的基本架构及其对食品供应链中所有参与者在信任及其在供应链中的整体地位的影响的问题。

为全面理解区块链对消费者参与和信任的影响，本文首先梳理在讨论区块链时最突出的学科之一经济学领域相关文献，回顾了有关促进消费者参与的更广泛研究，以深入了解如何有效地动员消费者参与食品安全治理。同时，分析了消费者信任领域的社会学文献，最后，通过对跨学科文献的分析研究，发表对当前实证发展的批判性见解，并简要展望未来的研究方向。

1 信息不对称的问题

在食品供应链及其治理方面，如 Antle[27]、Starbild 等[28]和 Hobbs[29]等经济学家所指出，信息不对称是阻碍食品供应链信息公平分配的关键问题，当前食品供应链中透明度不足和信息获取困难，尤其对消费者不利。区块链技术凭借其去中心化的特征给出了解决信息不对称问题的可能性，有助于赋予消费者权利，增强消费者信任。根据 Riasanow 等[10]的观点，消费者不再依赖特定个人、中央权利机构、监管机构或第三方验证机构的治理和验证。区块链的数据驱动架构通过自动记录供应链中每个阶段的运输收据和食品安全信息，促进透明度、可追溯性和问责性。通过共识算法验证这些共享信息的真实性，以确保信息的可靠性和可信度。因此，在共识算法范围内，区块链的使用将责任和信任认知从中央权利机构、监管机构和第三方验证者转移到包括消费者在内的所有食品供应链参与者共同治理和参与。在这种背景下，未来应进一步分析区块链的去中心化架构如何在食品供应链内重新分配角色和责任，以及它如何影响包括消费者在内的新的关键参与者之间的信任感。

2 共同治理和消费者参与

关于确保食品安全的责任与能力的归属在学术界有着广泛讨论。一些学者[30-31]认为这是政府的根本职责，是政府保护公民福祉的基本义务。然而，另一些学者强调，为了确保食品安全，监督需要建立在涵盖所有相关参与者的协作体系基础之上。此外，多个学科的学者[4,8,31]主张采用一种分权共治模式和更加透明的食品属性信息共享机制。他们认为单靠政府的力量难以全面监管和监督市场，因为缺乏如此广泛的治理资源，责任也太大。此外，共治具有对于保障供应链食品安全及减少政府监管成本的重要性。因此，实现多方参与的食品安全治理，对于提高消费者信任至关重要，这要求促进公共机构与私营部门的合作[32-33]。

共治的概念着眼于让公民（也是消费者）积极参与食品安全监督，与中心化的食品追溯系统形成鲜明对比，在后者中，公民仅作为被动的终端消费者[34]。

认为消费者参与是这种新型食品安全治理方法的关键因素，因此有必要评估基于区块链的食品可追溯系统在增强消费者对食品治理信任方面的潜在优势。需要进一步的实证分析，才能将区块链作为一种新兴的食品可追溯系统，与条形码方案等集中自上而下的监管方式和其他分散的方式（如标签和认证模式）进行比较。

3 消费者信任的构建

信任在人际交往和沟通中起至关重要的作用，是社会系统理论化的一个基本概念。根据 Niklas Luhmann 提供的信任常用定义[35]，信任为一种预期，即在特定情况下（客观对象），信任者相信受托人会采取预期的行动或做出决策。信任具有三个要素的特征[36]：信任者、受托人和信任对象，而信任正是基于这些对象而存在。Luhmann 认为[35]，信任作为一种降低社会复杂性的机制，帮助个体预测他人的行为，从而使社会互动更高效。

在消费者信任的框架下，消费者信任基于过往经验、认知，以及公司或组织的声誉，还包括消费者所在行业或市场的普遍信任。消费者信任特指消费者对某个品牌、产品或服务等的信息程度，包括对所有参与方承诺提供优质产品或服务并采取道德和负责任行动的信任[37]。然而，这也意味着消费者信任同样涉及食品供应链中所有参与者的角色和责任。尤其是在区块链技术的背景下，预期这一技术将重塑供应链中各方的角色和

责任，对此需要批判性的理解和评估。

不同的学者对消费者信任的概念有不同的理解。为了提供一个全面的主题概述，Benson 等[38]进行了一项跨学科的文献综述，重点关注有关消费者信任和食品供应链的文献。这次综述确定了消费者信任的最常见方面，包括一般信任、人际信任、组织信任、产品信任和链信任。对他们来说，一般信任是一个抽象的概念，指的是个体在日常交往中对其他个体和社会系统的可信赖性和可预测性的期望。与人际信任不同，组织信任不依赖于对特定个人的了解，而是基于对食品供应链中间接参与的特定组织的信赖。与此相对，链信任专指对食品供应链中直接参与者的信任。在产品层面上，消费者信任包括对食品标签、认证和产品来源等信息的真实性和准确性的信赖。

总之，在食品安全治理的环境下，消费者信任是一个复杂的、多面的概念。从区块链的角度来看，增强消费者信任的基础是通过区块链技术让消费者参与治理过程本身。换句话说，信任的概念正在经历一场转变，这需要分析技术是如何影响不同参与者的角色和责任，以及这反过来又是如何影响信任构建的。然而，在这一背景下，缺乏对不同行为主体信任观念和理解的理论与实证理解、比较和整合。

4 讨论与结论

在全球食品系统内引入区块链技术，作为解决消费者信任缺失的新途径。这项技术通过增强可追溯性和促进所有参与者的共同参与，基于一种共识算法，可减少对（可能不可靠的）人为中介依赖。通过对区块链技术的初步实施和相关文献的分析，本文提出了几个需要进一步研究的问题，以确定区块链是否可以创建一个更安全的食品系统并增强消费者信任。建议今后研究应关注从中间机构之间的信任转向对技术本身的信任，特别是对算法和基于点对点网络的信任，同时从理论和实证的角度探讨这种转变的意义。在这种背景下，随着消费者角色和责任的不断演变，研究食品供应链参与者对信任的理解和认知如何影响区块链的设计和使用及其对消费者的影响至关重要。对消费者而言，重要的是确定区块链技术对他们对新食品系统信任的影响，尤其是在比较其他已建立的食品追溯系统时，对食品完整性和技术完整性的影响。随着区块链技术在全球食品供应链中的应用日益广泛，在考虑未来研究时，评估其对不同国家信任水平影响的重要性日益凸显。通过对现有文献的批判性分析，本文强调了进行更多理论和实证研究以深化对信任概念理解和概念化的必要性。

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Blockchain-enabled Consumer Engagement: An Emerging Pandora to Safer Food and Enhanced Consumer Trust? (英文原文)

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Abstract: Currently, there is a growing call for a co-governance approach that includes consumers in food safety governance. To address this, corporations have implemented decentralised digital food traceability systems based on blockchain. Many argue that this technology will lead to enhanced consumer trust in food safety governance through greater consumer engagement. In this regard, this paper examines factors that influence consumer engagement and trust in food safety governance, mobilising interdisciplinary literature from the social sciences, economics and food safety governance. By doing so, it explores the implications of the implementation of blockchain as a means of enhancing consumer trust. The paper raises critical questions on a global scale and offers a social science and wider empirical perspective that has received less attention. To further investigate the effects of blockchain on consumer trust in the food supply chain, it proposes a research agenda that includes theoretical and empirical research.

Key words: food safety; consumer engagement; blockchain; food traceability; trust

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1 INTRODUCTION

According to the data of the European Food Safety Authority [1], numerous food fraud cases were reported across the world, involving various products such as meat, alcoholic beverages, milk and dairy products, and vegetables. Food fraud can occur at different levels. In this regard, it is important to distinguish between food fraud and food safety incidents, as the intent to harm public health and the environment is a crucial factor that sets them apart [2]. Thus, many but not all food fraud incidents are related to public health. Some can be classified as a deliberate deception of consumers, e. g. for financial gain on the part of producers[3]. Even without implications for public health, such food frauds may lead to reputational damage on part of the corporation and a negative effect on consumer trust in corporations and the regulatory authorities. Food fraud is defined by Spink and Moyer[3] as “the deliberate and intentional substitution, addition, tampering, or misrepresentation of food, food

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ingredients, or packaging; or false or misleading statements made about a product for economic gain". Despite the implementation of numerous measures to prevent food safety outbreaks, such as DNA tests and Hazard Analysis Critical Control Points (HACCP), by regulatory agencies and food companies, food frauds continue to represent a significant challenge[4]. In addition, Giampietri et al.[5] draw attention to the challenge of establishing consumer trust in complex global food supply chains. They stress the significance of sustainability, food safety, and security, and the need for a comprehensive focus on these issues. However, achieving this arguably requires significant restructuring of how food safety governance is approached. Many scholars call to approach food safety governance holistically, with the engagement of multiple actors [6-8].

In this context, number of corporations have proposed a blockchain-based system to enhance consumer trust and transparency though co-governance and consumer engagement. Blockchain is already widely used internationally to support logistics and optimize supply chains. It is commonly associated with cryptocurrencies for payments, as this is where the idea for its use originated[9]. Blockchain operates as a decentralised system, using a distributed ledger to create a secure and encrypted database[10]. By organising data into interconnected blocks[11], it ensures the integrity of information and prevents tampering. This is said to guarantee tamper-proof information for all actors involved, as any attempt to manipulate or change data would require altering the entire system. As an emerging multi-actor food traceability system, blockchain is embedded in the concept of co-governance, using a peer-to-peer approach and a consensus algorithm for verification introduced by Nakamoto in 2008 [9]. This approach aims to establish trust and ensure the validity and reliability of information along the supply chain, ultimately working towards the goal of safer food and minimising fraudulent or opportunistic behaviour by individual participants[12-13].

The use of blockchain in the food supply chain is said to provide consumers with traceable information from farm to fork, enabling them to access and contribute to details on the quality, safety, and product information of food products. By scanning a QR code on the food product, consumers, as well as any actor inside or outside the food supply chain, can access all the blockchain-verified information stored. Following the idea of enhancing consumer trust though more transparency and engagement, more and more national and international food corporations are adapting blockchain as a new food traceability system. An international hypermarket in China was among the first to implement a system that merges blockchain technology with food safety governance and traceability. In recent years, several European supermarkets have also begun to implement blockchain for some of their food products. Therefore, the implementation of blockchain in the food supply chain is an emerging trend in food traceability, highlighting the need to understand its implications on a global scale.

From a scholarly perspective, the use of blockchain in the food supply chain has been extensively discussed in the literature from a technology innovation [14-18] and from a management perspective [19-21]. However, little is done to mobilize a social science perspective [22-25] to understand the impact of blockchain on trust and the changing roles of actors in the field. Scientists such as da Silva and Moro[26] call for further researcher to address this gap. From a social science and wider empirical perspective, blockchain raises questions about the fundamental architecture of trust and its implications for all actors in the food supply chain in regard to trust and their overall position in the supply chain.

In order to gain a comprehensive understanding of the impact of blockchain on consumer engagement and trust, the following section will first review literature from the field of economics, as this is one of the most prominent disciplines when discussing blockchain. The next section will present wider literature on consumer engagement to gain a better understanding of how consumers may be mobilised and engaged in food safety governance. In addition, the field of consumer trust is analysed using literature mainly from the field of sociology. By reflecting on these interdisciplinary literatures, a conclusion section will shed critical light on current empirical developments and summarize further research questions.

2 THE ISSUES OF INFORMATION ASYMMETRY

In regard to the food supply chain and its governance, economists such as Antle[27], Starbild et al.[28], and Hobbs[29] have identified information asymmetry as a significant obstacle to achieving

equal distribution of information across food supply chains. They argue that the current food supply chains often lack transparent and accessible information, which puts especially consumers at a disadvantage. Blockchain's decentralized nature is believed to empower consumers and enhance their trust by addressing the issue of information asymmetry. According to Riasanow et al.[10], consumers no longer need to rely on specific individuals, central authorities, regulatory agencies, or third-party verification actors for governance and verification. Blockchain's data-driven architecture promotes transparency, traceability, and accountability by automatically generating transport receipts and food safety information at each stage of the supply chain. The authenticity of this jointly shared information is verified through consensus algorithms to ensure reliable and credible information. Consequently, the use of blockchain shifts responsibility and perceptions of trust from central authorities, regulators and third-party verifiers to co-governance and engagement of all actors involved in the food supply chain, including consumers under the umbrella of the consensus algorithms. In this context, it is necessary to further analyse how the decentralized architecture of blockchain redistributes roles and responsibilities within the food supply chain and how it affects perceptions of trust among the new key actors, including consumers.

3 CO-GOVERNANCE AND CONSUMER ENGAGEMENT

There is considerable disagreement in the literature about which actor(s) is (are) responsible for, and capable of, ensuring food safety. Some scholars [30-31] have argued that this is the fundamental responsibility of the government and its goodwill to protect its citizens. However, many argue that supervision should be based on the cohesion of all actors involved to ensure food safety. In addition, scholars from different disciplines [4,8,31] observe a form of decentralized co-governance and a more transparent form of sharing food attributes and information. They argue that governments alone cannot regulate and supervise the entire market because it lacks the resources for such extensive governing. The responsibility is too great. Co-governance is needed to ensure better food safety along the supply chain and to reduce costly government monitoring. Consequently, multi-actor involvement in food safety governance is necessary to enhance consumer trust. This requires the public and private sectors to work together [32-33]. Co-governance is often understood to involve citizens, who are also consumers, to become active participants in the food safety supervision process. This is in contrast to centralized food traceability systems, where citizens are only passive end-consumers[34].

As consumer engagement is regarded as a crucial factor in this novel approach to food safety governance, it is necessary to assess the prospective advantages of blockchain-based food traceability systems over current methodologies in enhancing consumer trust in food governance. Further empirical analysis is required to compare blockchain as an emerging food traceability system with centralised top-down supervision approaches, such as barcode programmes, and other decentralised approaches, such as labelling and certification schemes.

4 CONSTRUCTION OF CONSUMER TRUST

Trust plays a crucial role in human interaction and communication and is a fundamental concept in the theorisation of social systems. One of the most cited definitions of trust is provided by Niklas Luhmann. He [35] defines trust as the expectation that a person (trustor) can rely on the actions or decisions of another person (trustee) in a given situation (object). Therefore, trust is characterised by three elements, namely the trustee, the trustor and the trust object, towards which the trust is directed [36]. According to Luhmann [35], trust emerges as a mechanism for reducing complexity in social systems, enabling individuals to predict the behaviour of others and making social interaction more efficient.

In its reliance on the concept of trust, consumer trust is based on past experiences, perceptions and the reputation of the corporation or organization, as well as the general trust of the industry or market in which the consumer operates. Consumer trust specifically refers to the level of trust that consumers have in, for example, a particular brand, product or service. It includes the belief that all actors involved deliver what they promise, provide quality products or services, and act ethically and responsibly in their practices [37]. However, this approach suggests that consumer trust is equally

understood towards the role and responsibility of all actors involved in the food supply chain. Particularly in light of blockchain, which is said to change the roles and responsibilities of all actors involved, this approach needs to be critically reflected upon.

The concept of consumer trust is understood in different ways by various scholars. In order to provide a comprehensive overview of the subject, Benson et al.[38] conducted an interdisciplinary literature review focusing on literature dealing with consumer trust and the food supply chain. This review identified the most common aspects of consumer trust. These include multiple determinates of trust, namely general trust, interpersonal trust, organisational trust, product trust, and chain trust. General trust, for them, is an abstract concept that refers to the expectation that individuals have in the trustworthiness and predictability of other individuals and social systems in their daily interactions. Organizational trust differs from interpersonal trust in that it does not require concrete personal knowledge. It refers to the trust in a specific organization that is indirectly involved in the food supply chain. In contrast, trust in the supply chain refers to the actors directly involved in the food supply chain. At the product level, consumer trust includes trust in the authentication and correct display of information such as labels, certifications, and product origin.

To summarize, consumer trust in the context of food safety governance should be understood as a complex, multifaceted concept. From a blockchain perspective, enhancing consumer trust is based on engaging consumers in the governance process itself through the blockchain technology. In other words, the concept of trust is undergoing a transformation, which calls for an analysis of how exactly the technology is impacting the roles and responsibilities of the different actors and how this, in turn, affects constructions of trust. However, so far, there is a lack of theoretical and empirical understanding, comparison, and integration of different actors' perceptions and understandings of trust in this context.

5 DISCUSSION AND CONCLUSION

The emergence of blockchain is offered as a potential solution to the lack of consumer trust in the global food system, as the technology provides an approach to extend traceability and involve all actors. Thereby, blockchain is based on a consensus algorithm that reduces the need for (potentially unreliable) human intermediaries. By analysing the initial implementation of and literature on blockchain, this paper raises several questions that require further investigation to determine whether blockchain can create a safer food system and enhance consumer trust. It proposes to examine the shift from trust between intermediaries to trust in technology, specifically algorithms and the underlying peer-to-peer network, and to explore the implications of this shift from a theoretical and an empirical perspective. In this context, it would be crucial to study how food supply chain actors' understanding and perception of trust influence the design and use of blockchain and its implications for consumers, given their changing roles and responsibilities. From the consumers' perspective, it is important to identify the impact of blockchain on their perception of trust in the new food system to understand the effects on both food integrity and technology integrity, especially in comparison to other established food traceability systems. As blockchain becomes more widely adopted in global food supply chains, it is important to assess how it (may) affect(s) trust within and across local contexts when considering further research. By critically reflecting on the literature presented this paper highlights the need for further theoretical and empirical research on the understand and conceptualisation of trust.

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