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Opportunities of Blockchain Technology in Quality Control of Meat Production

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Abstract: This article analyzes the role and potential of modern digital technologies, particularly blockchain, in quality control within the production and supply chain of meat products. It discusses how blockchain enables traceability of product origin at every stage, enhancing safety, transparency, and consumer trust. The article also reviews international case studies, practical examples, and technological solutions.

Keywords: Blockchain, meat products, quality control, supply chain, digital traceability, food safety, traceability, technological innovation.

In recent years, consumer demand for food products has increased significantly, with special attention to the quality, safety, and authenticity of meat products. Meanwhile, issues such as supply chain manipulation, counterfeit products, and incorrect labeling have called for urgent technological intervention. In such a context, blockchain technology is emerging as a groundbreaking solution not only in finance but also in the food sector.

Quality control in the meat industry is among the most crucial fields of the modern agri-food system. Ensuring public health, adhering to hygiene standards, complying with veterinary requirements, and maintaining safety protocols throughout the production and distribution chain are of global importance. Traditional centralized quality control systems are often fragmented, disconnected, and inefficient in delivering real-time, trustworthy data, which negatively affects traceability and safety enforcement.

Blockchain, with its decentralized, immutable ledger system confirmed by all participants in the network, presents a promising solution to these problems. It records every transaction and event in a transparent, tamper-proof, and time-stamped format. In meat production, blockchain can document every step—from farm to table—thereby enhancing accountability and minimizing the risk of data manipulation.

When combined with IoT (Internet of Things) devices, blockchain enables real-time data collection and storage. For instance, IoT sensors monitor livestock health, feeding schedules, veterinary interventions, and environmental conditions (temperature, humidity). During slaughtering, processing, and transport, these sensors log critical data—such as timing, temperature, and hygiene standards—which is then permanently recorded on the blockchain. Each transaction in this chain becomes a verifiable event, ensuring authen…

Empirical studies have confirmed the practical efficacy of blockchain in meat supply chains. For example, Spain's IberChain project developed a system to track the origin of Iberian pork. Using Near-Infrared Spectroscopy (NIRS) and bioimpedance sensors, they verified the genetic lineage of pigs. The results were stored via smart contracts on a blockchain ledger. In a study involving

830 samples, 83% genetic classification accuracy was achieved, helping to distinguish high-grade pork (e.g., jamón ibérico)…

Another case is BeefLedger in Australia, which applied Ethereum blockchain to digitize beef supply chains. It enabled full traceability of each cow—from birth to slaughter, storage, and delivery. This transparency boosted consumer trust, particularly in export markets like China, where food safety concerns are paramount.

Similarly, China's JD.com, in collaboration with meat supplier Kerchin, launched a blockchain solution using Hyperledger Fabric. Each product is tagged with a QR code before packaging, which consumers can scan to view the product's entire lifecycle—animal rearing practices, temperature records during transportation and storage, health diagnostics, and certification status. The project's success prompted other companies in China to follow suit.

These examples reveal several advantages of blockchain in the meat industry:

- Automation and transparency reduce human error;
- Real-time individual product traceability;
- Tamper-proof data recording enhances food safety and authenticity;
- Consumer-facing transparency boosts brand reputation and customer confidence.

However, several challenges remain. First, blockchain systems rely on accurate input data. The principle of "garbage in, garbage out" applies—if sensors or operators input incorrect or fraudulent information, blockchain only preserves it immutably. Hence, trustworthy sensors, accurate calibration, and external audit mechanisms are essential.

Second, the initial investment for implementing blockchain-based infrastructure is high. Costs include purchasing IoT devices, maintaining continuous internet access, operating blockchain nodes, programming and auditing smart contracts. These can be burdensome, especially for small and medium-scale producers. Nevertheless, in the long term, the return on investment can be significant due to improved efficiency, fewer losses, and a premium for traceable, high-quality products.

In conclusion, blockchain—when integrated with modern digital tools—provides a robust solution for addressing quality and safety challenges in the meat industry. Ensuring full traceability from farm to fork not only benefits producers but also regulators, exporters, and consumers. As this technology becomes standardized and linked with national and international oversight bodies, a digital revolution in food safety management is foreseeable. Its adoption in Uzbekistan's meat sector could elevate domestic product…

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