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Article

The competitive advantages of traceability: Constructing a theoretical framework for enhancing the competitiveness of tea enterprises

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Abstract: With the rising global consumer demand for green and healthy food, the tea industry is facing unprecedented competitive pressure. Therefore, how to build tea enterprises with sustainable competitiveness has become a key issue facing the industry. This paper firstly reviews the concept of traceability systems and their evolution and, based on the theory of enterprise competitive advantage, explores the influence mechanism of traceability as a strategic resource on the long-term competitiveness of tea enterprises; secondly, it analyzes the multi-dimensional role of traceability on enterprise competitiveness from five aspects, namely, quality and safety control and guarantee, brand image shaping and trust construction, market dynamics response and consumer feedback, risk response and product recall, as well as technological innovation and efficiency enhancement; finally, combined with the above analysis, this paper constructs a theoretical framework for the competitiveness of tea enterprises, integrates the impact of traceability in different dimensions, and proposes a multi-level competitiveness enhancement model. Through this framework, tea enterprises can more comprehensively understand and grasp the close relationship between traceability and the long-term competitive advantage of enterprises and then make strategic adjustments according to their own actual situation so as to realize sustainable competitiveness enhancement in the future market competition.

Keywords: traceability; competitive advantage; tea enterprises; sustainable development

1. Introduction

Food security has always been a solid foundation for achieving political stability, social harmony, and sustainable economic development (Long, 2007). In 1974, the Food and Agriculture Organization of the United Nations (FAO) first proposed the concept of “food security”, a term that is often misinterpreted as “food safety”. This term is often misinterpreted as “food security”. In the Chinese context, food safety is usually translated as agricultural product quality safety, food safety, food health safety, etc. (Zhang, 2018). In fact, food security has a broader connotation than food safety, which emphasizes that everyone has access to enough food to sustain a healthy life, and food security is a core component of food safety (Zheng and Zhao, 2003). Although there is no uniform academic consensus on the definition of food security, it is generally recognized that it covers the following three aspects: First, quantitative security, i.e., to ensure that food production is sufficient to meet the basic needs of a healthy life; second, regulatory security, to ensure the stability of food supply through the rational regulation of food prices and circulation; and third, qualitative security, to ensure that the public can enjoy safe and reliable food and to safeguard the people’s “safety on the tip of the tongue” (Gong and Wang, 2009).

With the increasing concern of consumers about food safety and product quality, developed countries such as the United States, the European Union, and Japan have successively introduced relevant laws and regulations to ensure food quality and safety and gradually established a perfect traceability system for food quality and safety (Ren and Xiu, 2008). Meanwhile, with the rise of blockchain technology, as a decentralized technology, it has gradually been applied to the traceability system, which effectively solves the problems of information sharing and data tampering and significantly improves the credibility and transparency of the traceability system. More and more enterprises, especially agricultural and food production enterprises, have begun to utilize blockchain technology to build traceability platforms to ensure product quality, safety, and information authenticity (Qian et al., 2020). As a traditional consumer product, the quality and safety of tea have increasingly become the focus of social concern. In order to cope with this change, the tea production model has also gradually transformed in the direction of green, organic, and traceable to improve the overall product quality and safety and to meet consumers' demand for healthy and safe food (He et al., 2022). In this context, the traceable tea system based on information sharing and cooperative control of the whole industry chain upstream and downstream has gradually become a key means to solve the problem of tea quality and safety. Through the establishment of a perfect traceability system, tea can be effectively tracked from production, processing, and circulation to sales of various links to ensure that the quality of the product can be controlled and safeguard its safety. Therefore, this study aims to construct a theoretical framework to explore how tea enterprises can gain competitive advantages through traceability and analyze how this advantage can be transformed into the core competitiveness of enterprises in the increasingly fierce market competition.

2. Theoretical overview

2.1. Concept and evolution of traceability

The concept of a traceability system can be traced back to the 1990s and was first proposed by the European Union in 1997 in response to the "mad cow disease" crisis. The system is based on information and sensing technology, which enables the tracking and tracing of goods by assigning a unique code to each product and retaining the relevant information (Opara and Mazaud, 2001). As shown in the **Figure 1**, nowadays, a traceability system is defined as a set of systematic management frameworks and technical means to realize the record and tracking of the whole life cycle of products from raw material procurement, production and processing, and transportation to final consumption. The core objective of the system is to ensure that the relevant information can be traced at each stage so that in the event of product quality problems, the problem can be quickly located and solved. This system covers the functions of data collection, storage, analysis, and traceability and is widely used in a variety of fields, such as food, pharmaceuticals, agriculture, manufacturing, and so on (Bechini et al., 2008). Specifically, the traceability system can accurately record and monitor the flow of products through the application of advanced technological means, such as bar codes, two-dimensional codes, radio frequency identification technology (RFID), and so on. In this way, the transparency and traceability of product

information in the production and circulation process are significantly improved, thus effectively guaranteeing product quality, strengthening enterprise risk management, and enhancing consumer trust (Bosona and Gebresenbet, 2013).

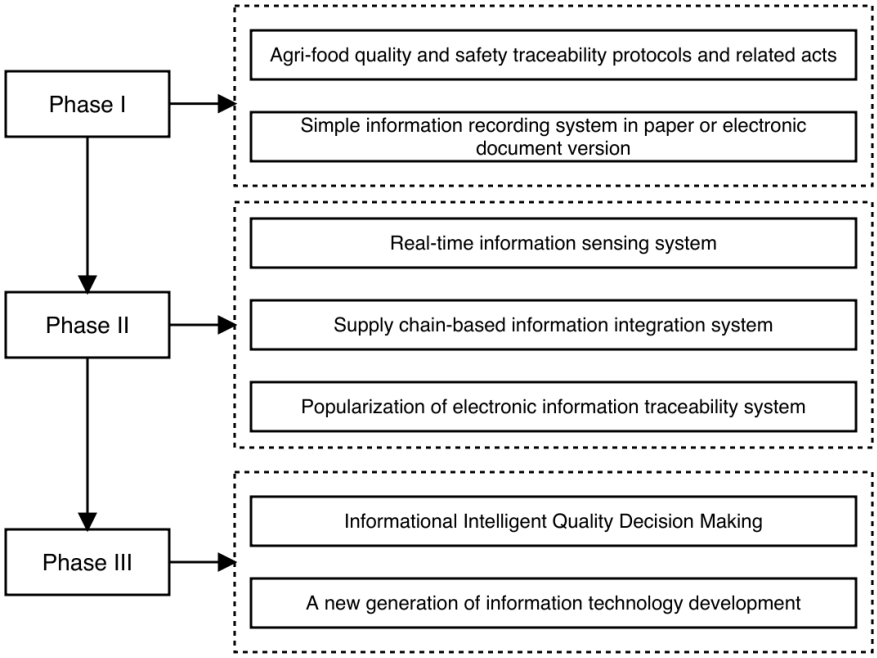

Figure 1. Traceability system development.

The development history of traceability systems can be divided into three main stages, gradually realizing a comprehensive upgrade from basic records to intelligent management (Golan et al., 2004). The first stage stores and manages simple information in the form of paper records or electronic files, mainly serving basic needs such as food safety. The information recording method in this stage is relatively traditional and single-function, but it lays an important foundation for the subsequent iteration of technology (Van Dorp, 2002). Entering the second stage, the wide application of agricultural information technology has promoted the comprehensive upgrade of the traceability system, realizing the digital and intelligent management of the whole process from the production end to the consumption end. Through the integration of electronic information, a comprehensive data platform of the "New Five Harmonizations" with standardization, informatization, industrialization, branding, and intelligence as its core has been established (Thakur and Donnelly, 2010). This stage significantly improves the efficiency and accuracy of information processing, strengthens the transparency and collaboration of the industrial chain, and provides consumers with more reliable product traceability services. Currently, the traceability system is moving into the third stage of intelligent "de-coding", which marks the deep integration of technology and user experience. Based on the wide application of near-field communication (NFC) technology, consumers do not need to scan the two-dimensional code to obtain detailed product traceability information but rather use the "cell phone touch" way to realize information interaction. Intelligent "de-coding" not only greatly improves the convenience of inquiry but also strengthens the security and privacy protection of data transmission (Pigini and Conti, 2017). With the continuous

progress of science and technology and the continuous upgrading of industry needs, the traceability system has developed from the initial single record management to a more complex and diversified system. Nowadays, with the extensive application of advanced technologies such as big data and artificial intelligence, the level of intelligence of the traceability system has been significantly improved, and it is able to realize the comprehensive tracking and management of the whole life cycle and the whole chain of products.

To summarize, the implementation of a traceability system by enterprises can bring many advantages. First of all, through the establishment of a perfect traceability system, enterprises can provide detailed information from production to sales, which greatly improves the transparency of product circulation. In the event of a problem, the enterprise can quickly trace back to the responsible party to ensure that the problem is located and resolved in a timely manner, thus effectively avoiding potential risks and losses; secondly, by comprehensively collecting and storing production and sales data, the enterprise ensures the accuracy and completeness of the information and supports real-time updating, which enhances the enterprise's responsiveness to market changes and quality problems and improves operational efficiency; thirdly, enterprises follow unified standards and specifications when implementing traceability systems to ensure standardization and consistency in data exchange while strengthening information security and privacy protection to enhance the efficiency of data interaction between enterprises and other enterprises and regulatory agencies; finally, as a management tool that meets the requirements of regulations, the traceability system is highly scalable, and enterprises can flexibly adjust it according to their own needs to adapt to the ever-changing market environment and policy changes, ensure its continuous adaptability and sustainability in future development, and thus promote the long-term and stable development of enterprises.

2.2. Theoretical basis of competitive advantage

Neoclassical economics regards the enterprise as an input-output system of resources and products and mainly researches how the enterprise chooses inputs and determines outputs; i.e., the enterprise is regarded as a "black box" and assumes that all enterprises are homogeneous. Therefore, competitive advantage comes from the effective allocation of resources. Enterprises maximize productivity and profits by optimizing the allocation of resources such as labor, capital, and land. Under this theory, competitive advantage does not come from a firm's unique strategy or innovation but is the result of natural allocation by the market through the price mechanism. If a firm is able to produce and satisfy market demand at a lower cost, it will be able to occupy a favorable position in competition (Friedman, 1953).

In the early 1980s, the theory of competitive strategy put forward by Michael Porter became the mainstream in the field of strategic management, the core of which is the Five Forces Model, which covers the five industrial structure forces of competitors, buyers, suppliers, substitutes, and potential competitors. The theory states that the formulation of corporate strategy is closely linked to the external environment (i.e., the market), of which industrial structure is the most critical external factor. Industrial structure determines the rules of competition, and the combined role of the

five forces in different industries varies according to the characteristics of the industry, which leads to differences in the profit level of different industries or the same industry at different stages of development, which directly affects the formulation of corporate strategy (Porter, 1980). Therefore, the core of enterprise strategy analysis is the industry, enterprise, and product; through the analysis of the five competitive forces, the enterprise can determine its own reasonable position in the industry, and through the implementation of the strategy, have an impact on these forces, so as to change the structure of the industry, or even reshape the rules of competition (Porter, 1985). The attractiveness of the industry and the firm's position in the market become the main source of competitive advantage. In order to maintain this advantage, firms need to continuously make strategic investments, build industry barriers, and consolidate their competitive position (Hil and Jones, 2009). However, this theory is essentially a structural-behavioral-performance (SCP) theory of industrial organization introduced into the field of corporate strategic management. Its main shortcomings are that it still treats firms as "black boxes", assumes homogenization of firms within an industry, and views strategic choices only as a product of the external competitive environment, ignoring factors such as internal growth and resource changes.

In order to solve the above problems, in the mid-1980s, some scholars developed the Resource-Based View (RBV) theory on the basis of the Intrinsic Growth Theory proposed by Penrose. According to this theory, an enterprise's profitability comes from its unique and scarce resources, which can produce lower-cost or higher-quality products, thus realizing higher efficiency. A firm's competitive advantage is not derived from the external market but depends on its internal unique resources, which are usually intangible, knowledge-based, and difficult to imitate, forming the firm's core competencies (Wernerfelt, 1984). Therefore, a firm's competitive advantage depends on the heterogeneous, hard-to-replicate, and efficient resources it possesses. In addition, firms have the intrinsic motivation to continuously accumulate and innovate these resources so that they can maintain their competitive advantage. According to this theory, when developing an expansion strategy, a firm first identifies its unique and proprietary resources, then determines the markets in which the benefits of these resources can be maximized, and finally chooses whether to enter these markets directly or to transfer the resources to related firms (Grant, 1991). Although this theory makes up for the shortcomings of Porter's model of competitive strategy, it also has certain limitations, such as focusing too much on the role of the internal resources of the enterprise and ignoring the impact of changes in the external environment on strategy. The criteria for resource identification are vague and difficult to operationalize in practice.

In order to overcome the shortcomings of the resource base theory, scholars such as Tice proposed the dynamic capabilities theory. The theory divides an enterprise's resources into four levels: The first level is the factors of production and public knowledge purchased by the enterprise, such as production standards, etc., which constitute the enterprise's basic resources but are not sufficient to become strategic resources. The second level is the firm's proprietary assets, such as trade secrets and special production processes, which are difficult to replicate because of their intangible nature. The third layer is the enterprise's capabilities, i.e., the management practices that effectively integrate production factors and proprietary assets, which

constitute the enterprise's competitive advantage over the market. The fourth layer is the dynamic capabilities of an enterprise, which emphasizes that when facing changes in the external environment, an enterprise must continuously innovate and integrate internal and external resources and capabilities to respond to changing market demands. The theory of dynamic capabilities enables firms to continuously create new competitive advantages under existing paths and market conditions (Teece, 1997).

To summarize, the formation and maintenance of an enterprise's competitive advantage depends on the combined effects of internal resources, capabilities and the external market environment. First of all, an enterprise needs to possess unique and hard-to-replicate resources, such as advanced technology, proprietary technology, strong brand, and unique corporate culture, etc., which provide sustained competitive advantages for the enterprise. At the same time, an enterprise's ability, especially its ability to integrate and utilize these resources, is a key factor in maintaining long-term competitive advantage. By improving production efficiency, optimizing management processes, and promoting product and service innovation, enterprises are able to build solid competitive barriers in terms of cost, quality, and service. In addition, the sustained maintenance of competitive advantage does not only depend on internal factors, but also requires adaptation and interaction with the external market environment. External factors such as market demand, consumer preferences, technological advances, competitor dynamics, and policies and regulations are constantly shaping an enterprise's competitive landscape. Therefore, the formation and maintenance of an enterprise's competitive advantage is a dynamic and interdependent process, which requires not only the continuous optimization of internal resources and capabilities, but also a sensitive response to changes in the external environment. Through continuous strategic adjustment and resource integration, enterprises can maintain long-term competitive advantages in the highly competitive market.

3. Mechanism analysis of traceability and competitive advantage of tea firms

3.1. Quality and safety control and guarantee

Quality and safety control and guarantee are the core of the traceability system, especially in the tea industry, to ensure that the quality of each link can be controlled and information transparency is the key to enhancing the competitiveness of enterprise products. Quality and safety control and security throughout the tea from production to circulation of each link, through strict management measures and advanced technical means, to ensure that the quality of tea is effectively safeguarded.

3.1.1. Production

In the production of tea, quality and safety control begins with the planting of tea trees. The application of a traceability system can record in detail the geographic location, soil type, climatic conditions, and water source of each tea plantation to ensure that the ecological environment meets the safe planting standards. The types, amounts, and application times of agricultural inputs, such as pesticides and fertilizers, used by tea farmers can be accurately recorded by the traceability system to ensure

compliance with national and regional safety standards for agricultural products (Lu et al., 2020). The use of pesticides and fertilizers is also strictly controlled by the traceability system to ensure that the tea complies with food safety standards and avoids excessive pesticide residues by monitoring their use, dosage, and date of application in real time. In addition, tea plantation managers use the system to track and record environmental factors during the planting process to ensure that no harmful substances are used, thus safeguarding the natural quality of the tea leaves.

3.1.2. Processing

The picking time of tea leaves has a significant impact on their taste and quality, so different picking times will affect the chemical composition of tea leaves and their flavor characteristics (Aaqil et al., 2021). With a traceability system, tea farmers can accurately record the picking time and method (e.g., hand-picking or mechanical picking) for each batch of tea, thus ensuring that the tea leaves are picked at their optimal quality period to ensure their flavor profile and quality standards. Meanwhile, key steps in the processing process, such as roasting, greening, and kneading, are also recorded in detail through a traceability system to ensure that each process is strictly controlled, thus reducing quality fluctuations due to improper processing (Lokunarangodage et al., 2015). The hygiene and safety of tea during processing is of paramount importance. Studies have shown that factors such as the temperature and humidity of the processing environment, the cleanliness of the equipment, and the quality of the air directly affect the safety and final quality of tea (Jiang et al., 2019). Through the traceability system, it is possible to monitor environmental variables such as the cleanliness of processing equipment, air quality, and temperature and humidity in the workshop in real time to ensure that these conditions are strictly in line with food safety requirements, thus avoiding the occurrence of tea quality problems due to environmental pollution.

3.1.3. Circulation

The circulation process of tea, including packaging, transportation, storage, sales, etc., may affect the quality of tea at each link. The traceability system in these links, through real-time monitoring and data recording, effectively avoids the interference of external factors on the quality of tea and is able to identify and solve potential problems in a timely manner (Xu et al., 2023). In the packaging link, the packaging of tea not only needs to meet the market demand but also needs to have the functions of moisture-proofing, mold-proofing, and freshness preservation in order to prolong the shelf life of the product and ensure the quality. A traceability system can record the selection of packaging materials and the packaging process to ensure that it meets food safety standards. Warehousing has strict requirements on the humidity, temperature, and other environmental conditions of tea leaves. With the help of a traceability system, companies can monitor the warehouse environment in real time and accurately record the storage conditions, preventing the quality of tea from deteriorating due to environmental problems. During transportation, the traceability system ensures that tea leaves are protected from damage during transportation by monitoring changes in temperature and humidity during transportation, transportation timeframe, and storage environment. In case of problems, the system can quickly locate specific batches and

transportation paths, providing data support for timely handling, thus guaranteeing the stability and safety of tea quality.

3.2. Brand image shaping and trust building

The application of a traceability system in tea enterprises can not only enhance the transparency of tea products but also provide strong support for brand image building and consumer trust. With the help of this system, companies can show detailed information about the origin, planting process, processing technology, and logistics path of tea, so that consumers can have a clearer understanding of the quality control and safety guarantee of each link (Chen et al., 2022). This not only highlights the uniqueness and high quality of tea products but also reflects the brand's long-term commitment to sustainability and food safety. At the same time, the openness and transparency of product information can help enhance consumers' recognition of the brand's professionalism and reliability, thus further consolidating the brand's high-end image in the market and helping tea companies to stand out in the fierce market competition.

In addition, consumer trust is considered a core asset for the long-term success and sustainable growth of any business. As consumers are increasingly concerned about food quality, the transparent brand image constructed by the traceability system can undoubtedly attract consumer groups who are health-conscious, concerned about quality, and have high requirements for food safety. By scanning the QR code on the product package, consumers are able to access detailed information about the tea in real time (Mangla et al., 2022). This efficient and transparent mechanism not only enhances customer satisfaction but also strengthens consumers' long-term trust in the brand, which in turn reinforces and maintains strong customer relationships. Through traceability systems, companies are able to effectively remove consumer concerns about the quality and safety of tea and build a deep foundation of trust.

3.3. Market dynamic response and consumer feedback

A traceability system is not only an information recording and management tool; it also has a powerful function of real-time collection, analysis, and processing of data from various links, such as tea. These data provide tea enterprises with an important basis for market trends and changes in consumer demand, enabling enterprises to respond to market changes more flexibly and efficiently.

Based on the previous introduction of traceable tea quality and safety control and guarantee, by accurately tracking the production, processing, and circulation path of tea products, tea companies are also able to sequentially monitor changes in consumer preferences in real time. Through the timely analysis of consumer feedback and real-time monitoring of market dynamics, enterprises can not only optimize the product design, production process, and service quality, but also find an entry point in consumer demand and market trends to meet the increasingly diverse needs of consumers. This precise response mechanism to market dynamics can help enterprises to quickly adjust their direction and avoid losing competitive advantages due to lagging market changes (Anastasiadis et al., 2021). At the same time, when consumers use the traceability system, they often provide their opinions and suggestions on

product quality, service, packaging, etc., and enterprises can collect this feedback through the traceability platform. By analyzing consumer feedback, companies are able to identify potential problems in their products and services and make timely adjustments. In addition, the traceability system can also help enterprises monitor the dynamics of their competitors and help them make more accurate market positioning and strategic decisions by analyzing information on competitors' product trends, pricing strategies, and marketing tactics.

3.4. Risk response and product recall

In the event of quality problems or food safety incidents, the traceability system can provide strong support for the response speed and accuracy of enterprises in crisis management. Through the traceability information recorded in the system, enterprises can quickly lock the affected product batches and circulation paths, so as to identify the problematic products at the first time and quickly track down the production, processing, and circulation links of the products through the traceability system to make clear the source of the problem and the scope of influence. Once quality problems or safety incidents are found, enterprises can immediately start product recall procedures with the help of the traceability system to ensure that the problematic products are quickly withdrawn from the market and to reduce the risks that may be posed to consumers' health and the reputation of the enterprise. In addition, the real-time monitoring function of the traceability system enables companies to accurately track the recall situation, ensuring that every affected product can be effectively traced and handled and avoiding any missing or omitted products from continuing to circulate in the market. At the same time, the traceability system can provide detailed feedback data throughout the recall process, helping companies to understand the efficiency of the recall, the handling of affected products, and consumer reaction.

3.5. Technological innovation and efficiency improvement

As an efficient information management and monitoring tool, the traceability system not only improves the transparency of the production process but also plays a crucial role in promoting technological innovation and production efficiency. With the help of the traceability system, tea enterprises can accurately control the key parameters in each production link, such as temperature, humidity, processing time, etc., which provides the necessary data support for technological innovation (Manning and Kowalska, 2021). Through real-time monitoring and data analysis, enterprises are able to discover and identify potential problems in the production process and then make technical adjustments and process improvements. At the same time, with the advancement of technology, tea enterprises have gradually introduced technologies such as the Internet of Things, artificial intelligence, and big data analysis, which, combined with the traceability system, can realize the automation and fine management of the production process. Through sensors and intelligent equipment, enterprises can monitor the production environment and equipment status in real time, automatically adjust parameters, and reduce manual intervention and errors, thus improving production efficiency and reducing production costs. The automated production method can not only enhance the stability of production but also effectively

shorten the production cycle and improve the consistency and quality of products. In addition, through data analysis, enterprises can also identify inefficient links in production and adjust production strategies in a timely manner according to changes in market demand. Finally, technological innovation is not only reflected in the improvement of production processes; tea companies can also utilize traceability systems to drive innovation in product development and marketing. The transparent data and detailed product information provided by the system provide strong support for enterprises to develop new products that meet consumer needs and significantly improve the speed of market response. At the same time, with this data, companies can accurately grasp market dynamics, optimize market positioning, and adjust product design and marketing strategies by tracking consumer purchasing preferences and feedback.

4. Traceable tea case practice

4.1. Anhui: Keemun black tea—"A code traceability" intelligent traceability system

Keemun black tea is a representative category of Chinese black tea, but it is also well-known historical tea and black tea boutique. 2024, in order to further improve the tea traceability system and promote the high-quality development of the tea industry, Keemun County is to Keemun black tea as a pilot, the establishment of a "one-code traceability" mechanism, to achieve the tea from planting to the consumption of the entire process of informatization traceability, for the modernization and transformation of the traditional tea industry provides a new path.

4.1.1. Data collection: Full quality supervision

By collecting information covering the whole process, including tea planting, picking, production and processing, quality inspection, warehousing, transportation, and other links, Keemun black tea has constructed a whole-chain quality traceability system from tea plantation to tea cup. The system uses advanced traceability and verification technology to realize the full traceability of products and information records while effectively preventing counterfeiting and eliminating fake and shoddy products and comprehensively enhancing the credibility of the quality of the product and brand influence. In addition, by generating a unique "electronic ID card" for each batch of Keemun black tea, consumers can scan the QR code or traceability code to conveniently obtain detailed information on the planting environment, processing technology, inspection report, and logistics track of the tea.

4.1.2. Chain supervision end: Intelligent traceability system

The Keemun black tea traceability system integrates traceability data statistical analysis and quality data control modules and innovatively constructs three major functional ports, namely, "consumer side, enterprise side, and supervision side", to fully meet the needs of different users. The consumer port helps consumers to quickly check the details of tea production, processing, quality testing, and logistics in a convenient and intuitive way, thus enhancing consumer confidence and satisfaction. The enterprise port supports enterprises to optimize production processes and improve operational efficiency through real-time data analysis and management tools while

effectively reducing quality and supply chain risks. The regulatory port provides government and industry regulators with chain-wide visualization and supervision tools through the integration of traceability data and quality control functions, which significantly improves food safety management capabilities. By building a unified system backstage management platform, Keemun black tea realizes the dynamic monitoring and precise control of the whole chain of tea from planting to consumption and promotes the industry's digitalization and intelligent upgrading.

4.1.3. Consumer traceability: Exclusive QR code traceability

Keemun Tea generates and posts an exclusive traceability QR code on the outer packaging of each product, providing consumers with convenient product verification and traceability services. By scanning the QR code, consumers can easily obtain detailed information about the product, including the whole life cycle data of raw material picking, production and processing, product packaging, factory inspection, storage of finished products, etc., which comprehensively realizes the transparency and full management of the tea production process.

Through the use of the exclusive traceability QR code, Keemun Tea not only makes the production information fully public, enhancing the transparency of the product and consumer trust in the brand, but also fully demonstrates the high importance of the enterprise in quality control and food safety. Consumers can intuitively understand the growth environment, processing technology, testing standards, logistics tracking, and other core aspects of the tea, so as to more confidently buy high-quality Qimen black tea. At the same time, this traceability mechanism effectively prevents the circulation of counterfeit and shoddy products, providing a solid guarantee for brand reputation and market reputation.

4.2. Zhejiang: West Lake Longjing Tea—Application of "blockchain" technology

As one of the top ten famous teas in China, West Lake Longjing Tea belongs to the green tea category, and its production area is located in the village of Long-jing Tea and its surrounding mountains in Hangzhou City, Zhejiang Province, which is named due to its unique geographic environment and has a long history of more than 1200 years. Through the introduction of "blockchain" technology for fine management, the level of brand protection of Long-jing Tea has been significantly improved, effectively curbing the circulation of counterfeit and shoddy products in the market and further consolidating the brand reputation and market status of Long-jing Tea.

4.2.1. Core production area and full traceability management

By clearly defining the core production area of Long-jing Tea and introducing an advanced digital management system, the annual verification of the area of Long-jing Tea plantations and the comparison of the sales volume can be implemented, ensuring that the production data of each tea plantation and each tea tree can be accurately recorded in the system. By comparing with the final sales volume of tea, the system is able to detect anomalies in a timely manner and prompt the intervention of relevant departments to ensure the transparency and traceability of the production chain (Paul et al., 2021). Meanwhile, with advanced climate monitoring equipment and drone

technology, the management of the Long-jing Tea plantation has become more efficient and intelligent. These technologies are able to collect real-time climate data, land moisture, and pest information, helping tea farmers and tea companies make scientific decisions during each growth cycle. The application of drones further improves the efficiency of tea plantation management, not only monitoring the conditions of the tea plantation in real time but also carrying out precise spraying and control work, ensuring that the tea-growing environment and production process meet the best standards, and realizing the traceability and efficient management of the whole process, from planting to processing (Hu et al., 2024).

4.2.2. Anti-counterfeiting traceability marking and data management

The non-tamperable nature of blockchain provides a high degree of authenticity and security for tea information, and consumers can verify the origin and quality of the product at any time. Through the introduction of blockchain technology, each batch of Long-jing Tea is endowed with a unique identity code, thus ensuring the full traceability of tea from production to sales. At the same time, the packaging of each batch of Long-jing Tea must be labeled with a special anti-counterfeiting mark, which, in combination with the special anti-counterfeiting mark, further strengthens the traceability management of the product (Gao et al., 2021). In addition, the production, picking, processing, and packaging of Long-jing Tea have been comprehensively digitized and managed by means of electronic accounts, QR codes, and IC cards. Each tea farmer and tea enterprise has an independent e-account, and the QR code and IC card ensure that every piece of data can be accurately recorded and updated in real time, which not only improves the transparency of the data but also provides the supervisory department with a convenient means of real-time monitoring to ensure the quality and safety of the products (Hu et al., 2024).

4.2.3. Quality inspection and credit system construction

In order to ensure the quality and safety of Long-jing Tea, the digital management system of Long-jing Tea was officially launched in 2020. The system has formed an effective mechanism for multi-party supervision by constructing a multi-level quality inspection system, covering three key aspects: Enterprise self-inspection, third-party inspection, and government sampling inspection. This system ensures that tea complies with strict quality standards at all stages of production, distribution, and sales. Enterprise self-inspection in the production stage to ensure product quality in line with internal requirements, third-party testing to provide objective and impartial quality assessment, while the government sampling to ensure that the market sale of tea is in line with national and industry safety norms, so as to fully ensure the quality and safety of the Long-jing Tea. Meanwhile, Long-jing Tea has further strengthened its quality management and brand reputation by building a digital credit model. The model can automatically calculate the credit value of tea farmers and tea enterprises; the quality control ability and business behavior of tea farmers and tea enterprises are monitored and reflected in real time through the establishment of integrity files to encourage trustworthy people to obtain market recognition, thus enhancing the brand image and market competitiveness.

4.3. Fujian: Fuding White Tea—Digitalized regulatory mechanism of "One product, One code"

Fuding White Tea is a specialty tea variety of Fuding City, Ningde City, Fujian Province, and has been awarded the China National Geographical Indication Product Certification. Through the introduction of the "Fuding White Tea Big Data Traceability Platform System", the quality and safety traceability system is continuously optimized, and a "One product, One code" traceability system covering the whole industry chain is constructed. This system runs through all aspects of tea plantation management, tea trading, production and processing, and terminal sales, ensuring that each batch of White Tea can be traced back to a specific production link and realizing whole-process quality monitoring and efficient management.

4.3.1. Digital quality tracing system

Fuding White Tea has always regarded the quality and safety of tea as the core of industrial development, and through the big data management model, digitalized supervision has been realized for all aspects of tea picking, trading, production, processing, and sales. This system assigns a unique digital "identity mark" to each batch of Fuding White Tea, ensures the authenticity and traceability of product information, and builds a full-chain quality and safety management framework from "tea garden to tea cup".

4.3.2. Quality and safety and brand value

Fuding White Tea continuously strengthens the quality and safety of tea, comprehensively promotes the implementation of the Fuding White Tea Big Data Traceability Platform System, and innovatively implements the tea voucher trading mode, which requires that tea products must provide traceability vouchers before entering the market, thus ensuring that every batch of Fuding White Tea comes from the place of origin and effectively protects the value of Fuding White Tea's regional brand. 2023, Fuding White Tea further consolidated its brand value in the market with the brand value of 6.070 billion yuan. In 2023, Fuding White Tea was valued at 6.070 billion yuan, further consolidating its leading position in China's tea industry.

4.3.3. Information sharing and market feedback

The "One item, One code" traceability system in Fuding White Tea's big data traceability platform is an important part of its quality and safety management. Each Fuding White Tea product is equipped with a unique traceability code, and by scanning the QR code, consumers can easily access detailed information about the product, including the place of origin, the year of picking, the planting environment, etc., so as to ensure the traceability of the product throughout the whole process. In addition, the system not only strengthens information sharing and collaboration among tea farmers, tea enterprises, and regulatory authorities, but also responds to market demand and quality issues in a timely manner through a real-time feedback mechanism, ensuring that every piece of Fuding White Tea circulates under strict quality supervision.

5. Theoretical framework construction of competitive advantage of traceable tea enterprises

Synthesizing the previous analysis of "traceability", enterprise competitive advantage and its mechanism, combined with the introduction of relevant cases, this paper proposes a theoretical analysis framework for the competitiveness of traceable tea enterprises. This theoretical framework emphasizes the key role of "traceability" characteristics on the transformation of the competitiveness of tea enterprises, highlights the constitutive factors of competitive advantage, and explicitly subdivides and categorizes the various processes in the management of tea enterprises, so as to facilitate a more systematic analysis and study of the competitiveness of enterprises. In this process, traceability is not only the basis of tea enterprise management, or the source of its competitive advantage, tea enterprises have the "traceability" characteristics to promote its competitiveness to enhance the core driving force. In practice, enterprises need to traceability characteristics and management of all aspects of the combination, make full use of this feature to optimize resource allocation and enhance the management effect. Through the effective integration of traceability features, tea enterprises can ensure product quality and safety, enhance brand influence, improve market management efficiency, strengthen the risk warning ability and improve product process innovation, thus promoting competitiveness.

As shown in the **Figure 2**, traceability and the competitiveness of tea enterprises can be divided into five key modules: Traceability quality control, traceability brand marketing, traceability market feedback, traceability risk management and traceability technology innovation. Each module not only relies on the full application of "traceability" characteristics, but also closely related to the actual process of tea enterprise management. Together, these five modules form a systematic competitiveness analysis framework that supports the sustainable development of tea enterprises in the marketplace.

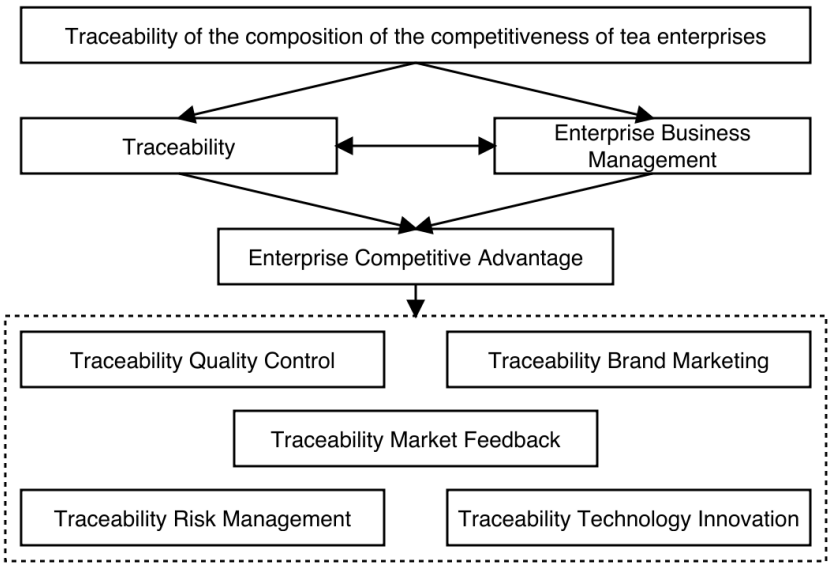

Figure 2. Theoretical analysis framework.

5.1. Traceability quality control

Traceability quality control is the unique core competitiveness of traceable tea enterprises, which can not only improve the market reputation of enterprise products but also enhance the trust of consumers and promote the sustainable development of enterprises. Quality and safety are crucial issues in the food industry, especially in the field of tea, a product that directly affects consumer health. The traceability system provides tea enterprises with a fully monitorable production and supply chain management mechanism. Every step from the source to the end can be recorded through the system to ensure that every step in the process of raw material procurement, production and processing, packaging, and transportation complies with regulatory requirements and industry standards.

5.2. Traceability brand marketing

Traceability brand marketing is the process by which traceable tea enterprises enhance their market operation ability and competitiveness through their unique traceability information system. By accurately identifying market demands and trends, reasonably utilizing market data for precise positioning, and displaying traceable information of tea products, such as planting environment, production process, and processing technology, enterprises can not only convey the unique value of the products but also enhance the transparency and credibility of the brand, attracting more consumers to pay attention to and purchase.

5.3. Traceability market feedback

Traceability market feedback is the process of collecting, analyzing, and responding to consumer feedback, changes in market demand, and product performance in real time through the traceability system of traceable tea enterprises. This process plays a crucial role in the competitive advantage of tea enterprises. Through the traceability system, tea companies are able to accurately grasp the market performance of their products and make timely adjustments to their products and marketing strategies based on consumer feedback. By tracking the production, sales, and consumer response of each tea product, companies are able to gain an in-depth understanding of consumer preferences, purchasing behavior, and potential demand, providing data support for product optimization and market expansion.

5.4. Traceability risk management

Traceability risk management is the process by which traceable tea enterprises utilize traceability systems to conduct real-time monitoring and management of risks that may affect product quality, safety, and compliance. By comprehensively recording and tracking every aspect of tea from planting, picking, processing to sales, the enterprise is able to identify potential risks in a timely manner, respond quickly, and take appropriate control measures. The core of the mechanism is transparency and verifiability, ensuring that companies can quickly locate the source of the problem and implement timely product recalls to prevent the problem from spreading. Whether it is a quality defect, a food safety issue, or a supply chain disruption, traceability

systems can provide detailed data support to help companies make accurate judgments and take effective countermeasures in the shortest possible time.

5.5. Traceability technology innovation

Traceability technological innovation is the application of innovative technology in all aspects of traceable tea enterprises to improve the efficiency, accuracy, and intelligence of the product traceability system. Its core lies in the application of intelligent equipment to optimize the production and processing of tea to ensure that each link can be accurately recorded and traceable. Through the application of traceability technology, enterprises are able to achieve accurate monitoring of the production process and real-time data analysis, which not only helps to improve production efficiency and reduce costs but also ensures that the quality standards of tea meet market demand through systematic tracking and data analysis and satisfies consumers' high demands for product safety and quality.

6. Summary

This study aims to construct a theoretical framework to explore how "traceability" can be used as a competitive advantage to enhance the competitiveness of tea enterprises. Through in-depth analysis of the application of traceability in the tea industry, the study reveals the role of traceability in enhancing the competitiveness of tea enterprises and proposes a relevant theoretical framework.

It is found that the traceability system can enhance the competitiveness of tea enterprises in multiple dimensions. Specifically, traceability quality control is the unique core competitiveness of traceable tea enterprises, which ensures that tea products comply with safety standards through comprehensive tracking and monitoring of product quality, thus enhancing consumer trust and reducing market risks. Traceability brand marketing is the process by which traceable tea enterprises enhance their market operation capability and competitiveness through their unique traceability information system. Optimize marketing strategies through real-time market feedback to enhance brand awareness and market share. Traceability market feedback is the process of collecting, analyzing, and responding to consumer feedback, changes in market demand, and product performance in real time through the traceability system of traceable tea enterprises. Through real-time monitoring of consumer demand and product performance, it helps enterprises quickly adjust their strategies and improve the market adaptability of products and services. Traceability risk management is the process of real-time monitoring and management of risks that may affect product quality, safety, compliance, etc., by using the traceability system of traceable tea. Through the monitoring and early warning of potential risks, timely identification and response to quality, compliance, and other risks, to protect the long-term stable development of the enterprise. Traceability technological innovation is the application of innovative technology by traceable tea enterprises in all aspects to improve the efficiency, accuracy, and intelligence of the product traceability system. Through the introduction of advanced technology to improve production efficiency and product quality, it promotes enterprises to maintain a competitive advantage in technology. The theoretical framework proposed in this study provides a specific

implementation path for the construction of traceability in tea enterprises and analyzes the application value of the traceability system in the tea industry chain from the perspective of competitive advantage, providing a theoretical basis and practical guidance for tea enterprises to achieve competitive advantage in the complex market environment.

However, this study also has certain limitations. Although this study constructs a theoretical framework based on traceability, the adaptability and feasibility of the framework in actual operation still need to be further verified, and because the implementation of traceability systems in different regions and tea enterprises varies greatly, each element in the framework needs to be dynamically adjusted according to the differences in the market, cultural background, and regulatory policies of different countries or regions. At the same time, as technology continues to advance, it may affect the effectiveness of the practical application of traceability systems. Future technological developments may make the existing framework and theories face the need for reassessment and adjustment.

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